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TESIS DOCTORAL
HUMAN RESOURCES, ENVIRONMENTAL
RISK AND IMPLEMENTATION OF LEAN
PRODUCTION. THE CASE OF THE FIRST
TIER SUPPLIERS OF THE AUTOMOTIVE
INDUSTRY IN SPAIN

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*“Everything will be all right in the end.
If it’s not all right, it is not yet the end.”*

— Simit Patel

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‘Keep going!’ my mother used to tell me reassuringly whenever I came across a challenging situation throughout my studies. After all, there are certain things in one's life that require a huge amount of commitment to bring off. Undoubtedly, however, the backing of people of good will whom you encounter along your way is as much important as having the will to carry on even if at the beginning you do not see clearly where the journey you are undertaking leads you. Indeed, the endeavor to pursue a PhD degree means the road less traveled. Not only metaphorically speaking, but in practical terms as well, since the candidate must dwell into a field of research and demonstrate that they are able to create something novel and push the boundaries of science forward in such a meticulous way that occasionally tests their limits. Therefore, every now and then you find yourself in need of guidance, which fortunately I never lacked.

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In Jaén, February 4, 2017

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INTRODUCTION

INTRODUCTION

Present doctoral thesis has the intent to make an impact via the identification of a number of internal and external factors in the environment of the company, which contribute to the explanation and extend the comprehension with respect to the implementation process of lean production in manufacturing firms. This novel understanding is deduced from the employment of an empirical analysis carried out among companies pertaining to the first tier suppliers of the Spanish automotive industry as well inferences based on a systematic analysis of the available literature on the subject are presented.

This is the introductory part of present doctoral dissertation that sets out the content through the adoption of a holistic approach for this purpose. The Introduction is structured into three interconnected parts. Firstly, a comprehensive explanation is provided with reference to the background of lean production. This way, it is hoped that an understanding is acquired by setting out the origins of this managerial system and unfolding the evolution of the concept of lean production as well as putting an emphasis on its expansion into different sectors of the economy. The second part revolves around the underlying motivation that finally led to the endeavor of undertaking this research. In the face of this, the objectives that were being sought and the research questions that the different chapters attempted to provide an answer are to be set out in this section. The methodological approaches that were resorted to are outlined to a detailed extent in the third part of the introduction. Finally, the overall structure of this thesis is discussed in the last part that also handles the content of the upcoming chapters, such as the main objectives and findings of each of them.

I. Background of the research

This part of the introduction chapter aims to provide an insight on the subject of the investigation with respect to lean production. Therefore, the birth of the concept of lean production is explained. The motivation for writing the thesis is set out as well, which is then followed by the objectives that were investigated and explored.

I.I The origins and evolution of lean production

The scientific literature usually describes lean production as a management system, which is based on the Toyota Production System or TPS (Holweg, 2007). The set of tools, which comprises said practices, was first used in the Japanese manufacturing industry and the term itself was devised by Krafcik (1988) in his article *Triumph of the Lean Production System* that was based on his master's thesis. As a continuation of his research with the goal of obtaining a better understanding about the challenges of the global automotive industry, Womack et al. (1990) enclosed their findings with the public in their international best-seller called *The Machine That Changed the World*. The ideas of the book were based on a five-year research with the aim of obtaining information about the future of the automobile industry under the framework of their project called *International Motor Vehicle Program* at the MIT. Their investigation is considered a milestone in the operations management (OP) research ever since, as in the book it is distinguished between traditional mass production systems and lean production.

Owing to Holweg (2007), the novel contribution of the Machine that Changed the World lays in the identification of key differences between lean production and the traditional mass production systems of the Western world that was prevalent at that time. Empirical evidence was provided to demonstrate that companies that implemented

the concept of lean production could produce considerably improved results as compared to the other type of mass production system. In addition, lean firms were observed to possess an enhanced ability in retaining their competitive edge. The most salient idea of the book comprised the fact that lean production is not only transferable to other organizations but that the concept can also be adapted in different sectors of the industry other than the automotive industry.

In order to create a tangible concept of lean production, the following simplification can be used based on the above. Lean production makes use of the concept learning organization and continuous improvement. With other words, a value stream for a given manufacturing process is created and then continuously improved as a way to achieve perfection. This is done by putting the whole system under investigation. Once an imperfection is identified, there is a plethora of disposable lean tools and techniques to make up for the error and improve the overall production process.

Since the establishment of the foundations on lean production research by Krafcik (1988) and Womack et al. (1990), there has been a spate of research into this particularly salient field of study. This research interest is a result of the complex environment and new challenges due to global competition in the industrial scene. In this context, the capability of manufacturing firms to preserve their competitive advantage has become more difficult, therefore they were compelled to adapt new manufacturing approaches, which are more oriented toward customer needs (Negrão et al., 2016). Among them, the most salient concept was lean production. Since the original researchers devised the term of lean production, a myriad of its aspects were subject to investigative scrutiny, which can be divided into two main epochs. In the 1990s, researchers usually focused on the “hard side” of the implementation of lean production. This included attention paid to technical details. Later, owing to the recurring number

of failures, this focus turned to the “soft side” that addressed people-related phenomena as well, as the integration of the hard and soft sides was deemed crucial (Sawhney and Chason 2005).

Nowadays, there is an agreement among scholars that the concept of lean production can be described as a set of philosophical tools (Moyano-Fuentes et al., 2012), which is in a state of continuous evolution and encompasses all levels of the organization (Womack and Jones 1996). The set of integrated socio-technical principles that comprises lean production aims to minimize all sources of internal and external system variability to the lowest extent (Shah and Ward 2007), that is, driving out any unnecessary expenses, which do not contribute to the creation of value (Zhou, 2016). Though the concept itself originates from the automobile industry, there has been a clear trend toward its adoption in different sectors of the industry as well (Shetty et al., 2010), such as the aeronautic industry and health care. In lean production research, the positive contribution of human resources and their management is relatively well established: employees’ motivation, their level of knowledge and skills are factors that are indispensable if a company opts for the implementation of lean production (Macduffie, 1995). Human resources can help provide employees with training, and thus, obtain the required sets of skills that can come handy when the transformation is made from a traditional production culture to lean production. Besides the above, there are papers that establish the role of the geographic context that companies operate in during the adoption and implementation of lean production, however, it has not been studied how it affects other aspects related to the variability of the environment in the implementation of lean production. Notwithstanding, it should be pointed out that most of the papers in lean production research have a focus on scrutinizing the adoption and implementation processes of lean production at the last level of the supply chain of the related industrial

sectors (automobile and aircraft manufacturers). The implementation process of lean production in the remaining levels of the supply chain has received far less research attention with the notable exception of Moyano-Fuentes and Sacristán-Díaz (2012). This way, the importance of putting first tier suppliers of aforementioned industries into investigation is important.

I.II. Motivation of the doctoral dissertation and its main objectives

In the setting of lean production, the implementation process brings about a significant change in the organizational structure of the company where failure was observed to be an inherent danger, with special regards to the initial stage of the transition process (Martínez-Jurado et al., 2014). This puzzling situation has led researchers to turn to the investigation of human resources and their management in lean production. This area is connected to the principles of lean production to a great extent given that the human factor and respect for people build a central aspect of lean production (Emiliani, 2007).

Companies usually opt for the implementation of lean production because they hope to achieve improved outcomes for their respective firms (Romano et al., 2010). In reality, however, there is compelling evidence that suggests that in case of a number of manufacturing firms and companies in the service sector, the implementation of lean production was not associated with more desirable results, thus the process resulted in a failure. The literature points out that the transformation to lean production is a complex process whereby the company needs to deal with a great variety of obstacles (Scherrer-Rathje et al., 2009). Therefore and owing to the lack of consensus with respect to factors that contribute to a successful outcome in terms of the implementation of lean production, researchers have been calling for renewed scientific scrutiny and more sophisticated research as to reveal the reason of why some companies do not manage to

obtain the enhanced outcomes associated with the implementation of lean production. Failures are usually linked to the lack of attention to the human element and the inability of the company to manage their changing internal and external environment.

With respect to the human element, its crucial importance has been in the crossfire of research interest since the second half of the 1990s. More precisely, researches turned to the investigation of human resources and their management after they had realized that besides the hard sides of the implementation, there are other aspects to consider (Bonavía and Marín-García, 2011), given the pivotal role of the workforce in the wake of a significant organizational and cultural change (Martínez-Jurado et al., 2013).

As lean production is usually associated with improved performance, managers were seen to opt for its implementation with the aim of obtaining a better position with respect to competitors (Tsai and Luan, 2016). Similarly, one of the underlying characteristics of lean production is that it deals with the variability of the external and internal environment (Shah and Ward, 2007). So far, however, research has mainly focused on either the internal or the external variability. Addressing both sources of system variability may facilitate the decision-making process of managers and contribute to the comprehension of success factors with respect to the implementation of lean production.

For all the above reasoning, present dissertation analyzes the role of internal and external changes, which are brought about by the implementation of lean production. The thesis revolves around two different types of environmental variability that influence the way managers make their decisions and therefore have pivotal inferences for both practitioners and scholars. On the one hand, the research takes into account the role of the variability of the environment in the implementation of lean production

(through firm risk) and on the other hand, the role of internal changes (variability in performance indicators) in the implementation of lean production. This way, the introduction of lean production has an impact on workers (internal change) and, ultimately, the operational outcomes of the company are also affected.

In this sense, this research studies how managers' decision-making process is influenced in the implementation of lean production and shows that decisions are adopted to reduce the variability of the environment of the company (that is a result of the advancements in the implementation of lean). This achieved by accounting for both:

- 1) changes in factors that are not directly controllable by them (firm risk) and

- 2) changes with respect to internal factors linked to the operational outcomes of the companies that are in fact controllable by the managers.

In the same vein, the thesis investigates the changes that are triggered internally by the implementation of lean production studying the impact it generates on the most prominent element of the lean principles, human resources, more specifically, the development of the workforce. Precisely, the importance of human resources in the implementation of lean production is what motivated an exhaustive review of the literature on the role of human resources in the implementation and consolidation process of lean by proposing a novel classification of the literature and which resulted in the identification of gaps and research challenges that should be addressed in a future occasion.

This doctoral dissertation attempts to address the aforementioned gaps by conducting research in the field of lean production and driving forward our comprehension on the subject of this management system. The thesis employs a

theoretical and empirical perspective and puts its emphasis on the implementation phase, the initial stage of lean production. More specifically, this serves to make up for the lesser amount of attention that is paid to this primary period of lean production. The underlying aim of taking advantage of such an approach lies in the potential identification of key factors that contribute to the understanding of success factors of the lean production implementation. This then can be made use of by managers and help obtain the improved outcomes associated with lean production.

The above explained factors of the research approach follow a strategic and a holistic point of view that reflects on the automotive industry in Spain. This investigation, however, has a different approach compared to the majority of the articles in this field, since the main focus is put on the first tier suppliers in the supply chain and not on the original equipment manufacturers. It has been set as an aim of this dissertation to analyze the role of these factors with respect to the implementation of lean production. From the point of view of the management, this analysis accounts for both the directly controllable factors and those that are out of reach of the managers. In addition, a special emphasis is provided to the soft side of the implementation of lean production. In this light, the crucial impact of human resources and their management has been given a special focus in order to determine its contribution to the successful outcome of the implementation process and its connection with the hard side of lean production.

The specific objectives of present doctoral dissertation can be broken down as the following:

- 1) To provide a systematic analysis of the available scientific literature on the field of lean production and human resources and their management with the aim of achieving the following main objectives:
 - To identify criteria that contribute to the establishment of novel classification of the literature.
 - To acquire the ability to group the literature into lines of research in the framework of the proposed classification.
 - To discuss the disposable empirical evidence on the subject and to propose new research directions based on the spots where gaps were identified for future investigation purposes and for researchers who want to delve into this topic.
- 2) To scrutinize the role of workforce development in the automotive industry and the way it contributes to the attainment of higher operational outcomes while concurrently facilitates the adoption of lean production in order to comply with the following goals:
 - To acknowledge the role of workforce development and its related practices as a success factor in the implementation phase of lean production.
 - To propose that workforce development and its practices contribute to the achievement of obtaining enhanced performance outcomes when they are taken advantage of in a manufacturing firm that has implemented lean production to a certain degree.
- 3) To expand the knowledge about how the environment, in which the company operates influences the process of the implementation of lean production, and facilitate the decision-making of managers when they want to deal with the

variability of the external and internal environment in the same time with the aim of providing coverage for the research objectives below:

- To identify the contribution of changes with respect to internal factors linked to the operational outcomes of the companies that are in fact controllable by the managers.
- To identify factors that managers do not have direct control of and their contribution of the change in these factors from the point of view of the implementation of lean production.

II. Methodological approaches

An in-depth literature review was carried out with the aim of complying with the first objective of the dissertation. The first aim was to carry out a systematic analysis of the literature on the field of lean production and human resources and their management and structure them into lines of research while concurrently gaps are identified. A systematic literature review (SLR) is considered to be a crucial step in structuring a field of study. In addition, it can enhance researchers' comprehension, facilitate the theoretical progress via developing theories, enable the deduction of progress by research and help new researchers who want to delve into this area, identify the contradictions and gaps pertaining to the literature. This reasoning provided the base of taking such a course of action.

Empirical research was employed in case of the second and the third objectives. This method corresponds to a systematical empirical investigation that aims to scrutinize observable phenomena through statistical techniques. The main goal of such an analysis is to contrast theoretical reasoning with statistical models. It is the process of

measurement that provides the fundamental connection with the empirical observation with the help of statistical tools (Given, 2008). Given the fact that in social sciences, quantitative method is the most prevalent way of making inferences, it was decided that this dissertation also employed aforementioned methodology to provide an answer to second and third the research objectives. One of the main advantages of the employment of such an approach is that it yields a resolution to a narrow line of research. A contra for using this methodology lies in the fact that given the narrow scope of research, any generalization based on the sample of the research with respect to the population as a whole is hypothetical in nature.

Data collection was carried out among the first tier suppliers of original equipment manufacturers that covered the entire Spanish automobile industry. For the purpose of collecting information about this sector, a questionnaire was developed which was then sent out to the manufacturing firms. Means of dissemination included conventional postal delivery services and e-mail. Among the informants one can find CEOs of the companies, heads of the human management department and directors of production and operations department. The population comprised a total of 216 that were derived from the database of SERNAUTO. In total, 84 duly completed surveys were sent back. The possibility of learning about the motives of companies that did not return a questionnaire arose, however, it was not possible to deduce a specific pattern to explain why some companies refused to answer. It was determined that the geographical distribution of the plants in the sample falls in line with the actual distribution of the population as a whole. The received questionnaires were evaluated and processed so that they could be used for the scientific purposes set out in the dissertation.

The relevance of the automotive sector for research purposes is axiomatic and lies in the fact that this industrial sector has always been the most receptive for the

implementation of lean production. In addition, the original Toyota Production System was also employed in the setting of the automotive sector. More specifically, as the theoretical foundations of lean production in this industry are already relatively well-established, it provides the opportunity to build upon them and push forward the boundaries of this field of study. In addition, given the aforementioned context, there is no need to carry out explanatory research, for instance in the form of a case study, as this methodology is more relevant for sectors that have recently become subjects to scientific scrutiny. Notwithstanding, this thesis had the opportunity to put its focus on the process of the implementation of lean production itself in case of companies that had adopted this kind of management system to different degrees.

During the conduction of the research, primary and secondary data sources were made use of as well. The main source of the primary data was based on the questionnaire, which was introduced afore. The Iberian Balance Sheet Analysis System (SABI) database served as a complementary database that was used to obtain financial and economic data about the manufacturing plants that took part in the research.

The different methodological specialties are explained to a greater degree in the corresponding chapters with the aim of achieve the research objectives stated in the previous part of this introduction.

III. Structure of the thesis

This doctoral thesis features three chapters, which address the three main research objectives outlined in the previous part.

The first chapter provides a systematic literature review with respect to lean production and human resources and their management. The reason of undertaking the

research in concern was to structure the available literature into distinguishable lines of research, reveal gaps and come up with challenges for future research in the field related to human resources and their management and help future researchers to engage with this field of study. The proposed lines of research facilitate the comprehension of researchers and practitioners on the subject of lean production and its success factors.

The second chapter handles the role of workforce development in the initial stages of the adoption of lean production and its impact on the degree of the implementation of lean production and their impact on operational performance. One of the contributions is that workforce development should be given focus in the same time when the company opts to advance to a further degree in the adoption of lean production.

The third chapter revolves around the subjects of self-reference on past performance and firm risk. These are external and internal factors that are either controllable by managers of a company or out of their reach. These aspects, however, have a crucial role especially in the implementation of lean production and are, therefore, important. The research questions in this chapter are answered via a set of hierarchical regression analyses. The main contribution of this chapter is that it helps managers undertake difficult strategic decisions in a sense that they take into account the level of risk of the environment when making decisions related to carrying out advancements in the implementation of lean production. Managers need to consider not only those factors that are controllable by them, but they should also be aware of those aspects that are out of their reach and can therefore not deal with them.

To conclude, each of the following three chapters begin with an introduction part, which outlines the motivation for conducting the research and the gaps that

provided the opportunity for undertaking the investigative study. The section in concern also points out the research question at the beginning of each chapter. Then it is proceeded to the establishment of the theoretical framework that is developed with the aim of providing a background for the hypotheses of the subsequent sections. This is then followed by the methodological part, which serves the aim of providing a resolution to the initial research question. The findings are then outlined in the part where the results are shown and then discussed in the conclusion. The conclusion also handles the theoretical and practical contribution of each chapter and provides future lines of research for researchers who would like to immerse in the given topic.

Finally, bibliographical references appear at the end of each chapter, but the references cited at the end of each chapter pertain to that specific chapter in concern. Figures, tables as well as footnotes are numbered separately for each of the chapters. This results in the numbering of them not following on from one chapter to another.

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CHAPTER 1.

LEAN PRODUCTION AND HUMAN RESOURCES: A SYSTEMATIC LITERATURE REVIEW

1.1. Introduction

In the last three decades, the industrial scene has faced novel challenges stemming from increased global competition (Wickramasinghe and Wickramasinghe, 2016) which caused operations and supply chains to grow in complexity at an unparalleled rate (Hu et al., 2008). In such a transitional environment (McAllaster, 2004), companies are compelled to implement a great number of changes in their operations in order to compete in dynamic markets (Noll, 2000). Consequently, companies have been looking at new ways to improve their business operations in order to remain profitable (Cauchick and Monteiro, 2014). As a result, such conditions have given rise to new manufacturing approaches (Hall, 1987), which are more oriented towards efficiency by eliminating internal and external sources of variability (Shah and Ward, 2003). In order for companies to retain their competitive edge, manufacturing firms have been prompted to adopt the particularly salient concept of lean production (Womack and Jones, 1996).

Recent days, lean production is considered to be a paragon for production optimization and a toolset for survival in a competitive global environment (Anvari et al., 2011). The multi-dimensional approach of lean production (Shah and Ward, 2003) comprises a complex set of manufacturing principles, which aims at streamlining the flow of production (Smith and Synowka, 2014), while the concept itself is based on continuous improvement (Womack et al., 1990) in eliminating any kind of waste (Shah and Ward, 2007). This turns the main focus to efficiency, while wipes away any kind of

bottlenecks (Hines, 2004). Subsequently, a number of companies from different industrial areas have been contemplating the implementation of lean production (Shetty et al., 2010). To sum up, Shah and Ward (2007, pp. 791) proposed the following the widely accepted definition of lean production which is also employed in present paper. *“Lean production is an integrated sociotechnical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability.”* In this sense, machinery and equipment should be highly automated and computer controlled, while human resources should be flexible and cross-functional to be able to operate the state-of-the-art machinery and also receptive to change and learn new approaches (Singh and Chauhan, 2013).

Despite the fact that the use of lean production by manufacturing companies started in the late 1980s, only a couple of them reached a truly lean system (Anvari et al., 2010). This was puzzling not only for managers but for researchers as well. Prior to the 1990s, the primary focus of research scrutiny was related to the technical aspects of the implementation of lean production (Bonavía and Marin-García, 2011). Later, owing to the recurring failures of the implementation this kind attention shifted to include people-related phenomena as well (Emiliani, 2007b; Martínez-Jurado et al., 2013). Therefore, the understanding of how people relate to conditions in a lean environment has become an important success factor (Tortorella and Fogliatto, 2014). This new research direction was somewhat expected to emerge given that the human factor and respect for people builds a central aspect of lean production (Emiliani, 2007a; Moyano-Fuentes and Sacristán-Díaz, 2012).

While lean principles have obvious ramifications for human resources and their management, the linkages between the two areas are not clearly established in the literature as well as in practice. Nonetheless, it has been argued that lean production

systems presuppose certain human resource management practices (Appelbaum et al., 2000). On the other hand, as a result of the human resources being strongly embedded in the national local context, standardization in this respect could face a number of difficulties (Jürgens and Krzywdzinski, 2013). More specifically, Engström et al. (1996) contend that the successful implementation of lean production in Japan can be attributed to the favorable conjunction of the socio-economic and socio-cultural circumstances. Another aspect, the role of work organization is underscored by Moyano-Fuentes and Sacristán-Díaz (2012) as an outstanding line of research on lean production. Nonetheless, a number of investigations unveil negative connotations of lean production when addressing human resources concurrently. More particularly, due to the fact that work becomes more intense after the implementation of lean production, workers receive a higher dose of stress (Fairris and Tohyama, 2002), while the monotonous and repetitive working conditions (Schouteten and Benders, 2004). These count towards the unfavorable effects of lean production on human resources (Moyano-Fuentes and Sacristán-Díaz, 2012).

The existent literature reports that nine out of the ten top barriers to lean production transformation are people-related (Tortorella et al., 2015), including poor communication and employee's resistance to change (Bhasin, 2012; Shook, 2010). Some authors suggested that dealing with such barriers involves implementing changes in organizational culture (Sawhney and Chason, 2005). However, existing organizational cultural status quo might be a barrier in itself (Sim and Rogers, 2009). Therefore, one of the key points for a successful transformation is the understanding of how people and organizations perceive changes when exposed to a transitional environment. In this light, Tortorella and Fogliatto (2014) make mention of a set of intangible components, such as the emotional state of employees. Consequently, there is

a spate of research that deals with the one or more aspects of human resources and their management in the implementation and consolidation phase of lean production. For this reason, the need has emerged for the organization of this scrutiny into distinguishable lines of research based on a guiding principle that takes into account previous empirical and theoretical articles of this field by carrying out an adequately sophisticated literature review.

In the past couple of decades, a number of explanatory research articles have attempted to put the role of human resources and their management in the early phases of lean production implementation under investigation. Recently, Stone (2012) analyzed and identified the phases of lean production research stemming from the inception of the concept. Concurrently, via incorporation of a significant number of related research articles, Bhamu and Sangwan (2014) contributed to the investigation of differences between the definitions of lean production in various papers and established the typical profile in lean production research. Beauvallet and Houy (2010) recognized the role of human resources management in the implementation and consolidation period of lean production in their literature survey and they combined knowledge about the two areas. These studies have only contributed to a certain extent to the comprehension concerning human resources in the early phases of lean production. For instance, Alagaraja (2014) focused solely on success factors and barriers to the implementation and sustainability of lean production from a human resources point of view.

There is a similarity among these previous papers in a sense that they took a specialized and partial approach on the relation between human resources and lean production. Present study, however, is different because of the segmentation of the research carried out with respect to the role of human resources in the implementation and consolidation phases of lean production.

Consequently, on the basis of the above reasoning, the main objective of this paper is to identify lines of research on the subject of the role of human resources and their management in the context of the implementation and consolidation of lean production. It is hoped that the widely available but fragmented pieces of literature can be pulled together efficiently so that it amplifies the ability of academics and practitioners to understand the role of human resources in the crucial early stages of lean production implementation. More importantly, light can be shed on the impact of human resources and their management a posteriori the initial introduction of lean production once the company has decided to take further steps in the implementation and consolidation process. This would allow the deduction of progress by the research, facilitate the work of new researchers who want to delve into this area, identify the contradictions and inconsistencies existent in the literature and specify the gaps or aspects of literature where further research is required. This paper focuses on both human resources and human resources management because they are closely related to the human factor and respect for people, some of the major principles of lean production (Emiliani, 2007a, b; Moyano-Fuentes and Sacristán-Díaz, 2012).

To provide an exhaustive answer to the research question, present paper is structured into four parts, with this first part devoted to introduction. The second section sets out the methodology employed in this paper. Subsequently, section 3 outlines the results of the systematic literature review, while the fourth section concludes that paper and highlights its main implications.

1.2. Methodology

This paper applies the systematic literature review approach and employs this methodology used by other researchers for related purposes (Stone, 2012; Martínez-Jurado and Moyano-Fuentes, 2014a, b). The role of human resources and their management in the implementation and consolidation process of lean production is an emerging aspect of this field. This mainly owns to the fact that the majority of the research articles have a focus on the technological aspects of lean production (Bonavia and Marin-García, 2011). In the meanwhile, researchers were called for more scrutiny in terms of the role of human resources in the adoption and implementation processes of lean production (Martínez-Jurado et al., 2013). Previous articles that have intended to link human resources and lean production have focused on narrow and partial aspects of the existing connections between the two areas. Thus, a comprehensive literature review carried out in a sophisticated and systematic manner would enhance the comprehension about the role of human resources in the implementation and consolidation process of lean production. For this reason, an in-depth evaluation was carried out of the relationship in the literature between lean production and human resources. A literature review can facilitate structuring a field of research, the development of theories and contribute to advances in knowledge (Martínez-Jurado and Moyano-Fuentes, 2014b). In addition, a systematic literature review may be of crucial importance for policy makers and academics (Tranfield et al. 2003).

Principles regarding the mechanics of a systematic literature review were sophisticatedly outlined by Tranfield et al. (2003). Present paper follows the guidelines set out by above researchers. First of all, the article should contain a section that explains the methodology (Greenhalgh, 1997) with the aim of avoiding biases (Mohrer

et al., 1995). This is achieved by providing the description of methods used for data collection and analysis. Then, a systematic literature review should aim to create a synthesized outcome so that the study acquires a holistic nature. The product, however, differs from a traditional literature review in a sense that the final outcome is likely to become a synthesis of the literature that explores the main lines of research and reveals areas in the literature that require to be subject to further scientific attention (Denyer and Tranfield, 2009).

1.2.1 Research design

The following section summarizes the measures taken to obtain the final set of papers considered in the systematic literature review (Martínez-Jurado and Moyano-Fuentes, 2014a, b; Durach et al., 2014). In this light, the first step was to determine the locations of the most prominent papers. For this reason, two steps were carried out.

Firstly, a pool of databases with the most significant pieces of literature had to be identified. The selected databases were ABI/Inform Complete, Scopus and ScienceDirect. These portals were chosen as they have some of the largest repositories of business research and are typically used in literature reviews (Carter and Easton, 2011). The publication of *The machine that changed the world* (Womack et al., 1990) marked the starting point of the time frame of this paper. Therefore, the search was limited to articles published between January 1, 1990 and October 31, 2016 to cover a period of 26 years. The bibliography included peer reviewed articles and paradigmatic books strongly related to the subject area of human resources and lean production. Dissertations, unpublished working papers as well as conference proceedings were excluded (Table 1.1).

Table 1.1. Main characteristics of the methodological approach

Unit of analysis	Research articles and prominent books with managerial impact that handle the linkages between lean production and human resources.
Type of analysis	Qualitative research.
Period of analysis	January 1, 1990 – October 31, 2016.

The keywords were determined after a careful examination of the literature. Keywords were selected based on the frequency they were used in the studies with the aim of selecting those which accounted for the highest number of occurrences (Martínez-Jurado and Moyano-Fuentes, 2014a, b) (Table 1.2). The final set of literature for the review was compiled in October 2016 to cover a period 26 years.

Table 1.2. Keywords employed in the searches conducted

<i>Lean management</i>	<i>Human resources</i>
Lean, Lean management, Lean production, Lean manufacturing, Lean production systems, Lean production implementation, Toyota Production System, TPS, Six sigma	Human resource, Human resources, Human resource management, HR, HRM, Blue collars, People, Workers

The keywords were then combined to construct various search strings which were employed in the database survey. Building upon Seuring and Gold (2012), this paper employed the following search strings (Table 1.3). As an additional criterion, with the aim of increasing the quality of the systematic literature review, the authors resorted

to articles that are registered in operations management journals from the Journal Citation Reports (JCR) published annually by Thomson Reuters. No further criteria were applied to carry out the search.

Table 1.3. Search strings for database search

Scopus	<i>TITLE-ABS-KEY ("lean production" OR "lean management" OR "lean manufacturing") AND TITLE-ABS-KEY ("human resources") AND DOCTYPE (ar) AND SUBJAREA (mult OR arts OR busi OR deci OR econ OR psyc OR soci) AND PUBYEAR > 1990 AND (LIMIT-TO (LANGUAGE , "English"))</i>
ScienceDirect	<i>TITLE-ABSTR-KEY("lean management" OR "lean production") and TITLE-ABSTR-KEY("human resources" OR "human resource")[All Sources(Business, Management and Accounting)]</i>
ABI/Inform Complete	<i>all("lean management" OR "lean production" OR "lean manufacturing") AND all(("human resource" OR "human resources"))</i> <i>– Additional limits: Date: From January 01 1990 to October 31 2016;</i> <i>Language: English</i>

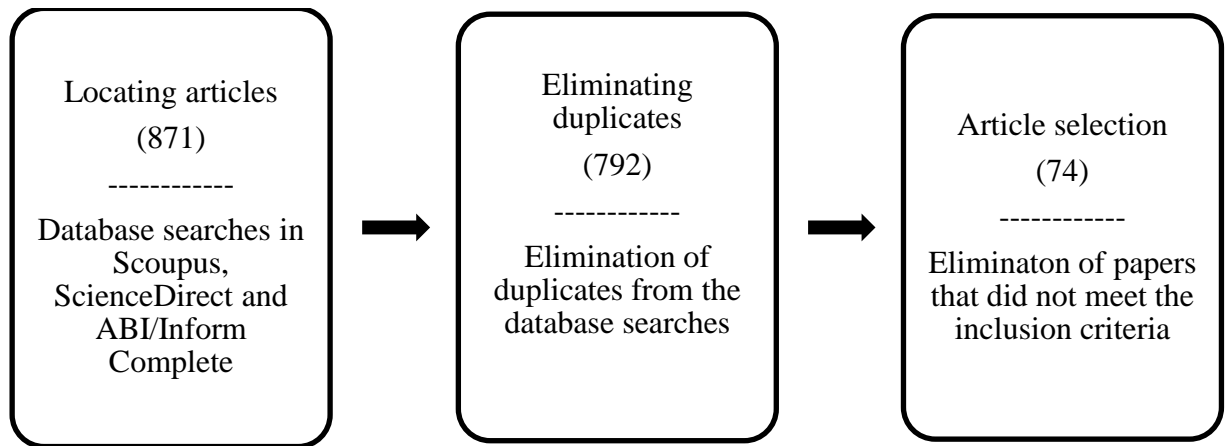
The literature survey conducted based on the aforementioned methodology yielded a total of 871 articles. Despite the different search approaches, the searches provided a number of overlapping results that can be seen as an indication for substantial consistency of the search strings. After the incipient complication of papers was obtained, the first step was the elimination of the duplicates. This left 792 articles.

The raw sample was then manually searched for any irrelevant articles. For this purpose, a random subset of 20 titles and abstracts was created with the name of the author(s) and the year of publication being concealed. This subset was then read independently by the authors to identify inclusion criteria. Subsequently, all the articles were screened and assessed based on the carefully established criteria through reading the titles and abstracts. This step was necessary to ensure that the main contribution of the papers revolved around the association between human resources management and lean production. Whenever disagreement occurred due to the information provided in the abstract or in the title not being sufficient to decide on their inclusion, the authors resorted to read the full paper instead. The inclusion criteria served as a refinement to increase the robustness of the electronic search strings in the three online databases and to make certain that the articles are within the framework of this study. The insight of the authors corroborates the viability of the inclusion criteria set up by Durach et al. (2014) (Table 1.4). The above-explained analysis led to the inclusion of 74 articles (Figure 1.1). In the subsequent step, the set of articles was surveyed as to produce a classification based on their main contribution with the aim of grouping them according to lines of research. In this procedure, the following actions were undertaken individually by the researchers. First, the researchers of this paper analyzed the research question of each article with the aim of coming up with the key characteristics pertaining to human resources management and lean production. Then, these key aspects were grouped on the basis of similarities and/or relatedness. Finally, owing to the results of the previous steps, lines of research were proposed. The insights obtained independently as a result of this process were then pooled and resolved jointly by the authors to establish the classification of the corresponding literature into lines of research that is detailed in the upcoming section of this paper.

Table 1.4. Inclusion criteria

<i>Criteria</i>	<i>Rationale</i>
1. The title and/or abstract make an explicit mention of lean production and human resources.	Some authors deliver their studies in the area of lean production or human resources but the two fields are not unconnected in the research.
2. The primary focus is on the analysis of human resources in the theoretical or empirical environment of lean production.	The authors present either a theoretical or a research paper with the emphasis being on the aspects of human resources in a lean environment. Studies using HR practices unrelated to lean production are out of the scope of this research.
3. The title and/or abstract demonstrate that the authors conduct research in the area of lean production.	Since present research is not restricted to specific journals, articles must conduct lean production related research instead of just mentioning the term and be published in a peer-reviewed journal.
4. The article is written in English.	Due to the fact that journals with the highest impact factor are exclusively in English, enacting this criterion may ensure the high quality of the sample.

Figure 1.1. Article selection process



1.3. Results and discussion

The above-mentioned procedure allowed the identification of four major research topics anchored in the interrelationships of human resources and their management and lean production. These research lines can be set out by taking advantage of the following grouping into lines of research: 1) Socio-cultural factors, 2) Work organization, 3) Trade unions, and 4) Knowledgeable workforce and participative management.

Table 1.5 sets out this proposed classification with the list of articles that were ascribed to each of the suggested lines of research in alphabetical order. Given the multidimensional point of view of lean production, it should be noted that some of the articles appear under more than one category since a given study may have connections with socio-cultural factors while concurrently may be pertinent to trade unions as well. Appendix 1 provides a brief summary of each of the papers included in the analysis. The following section addresses each of the lines of research to a detailed extent. Special emphasis is placed on inconsistencies and contradictions that were detected during the execution of this systematic literature review.

Table 1.5. Literature classification

Line of research	Main articles
Socio-cultural factors	<p>Adler (1993); James and Jones (2014); Lee and Peccei (2008); Lewchuck et al. (2001); Liker (2004); Lincoln and Kalleberg (1990); Lowe et al. (1997); Moreno (1999); Niepce and Molleman (1996, 1998); Oliver et al. (1994, 1996); Portioli and Tatardini (2008); Salaheldin (2005); Saruta (2006); Scherrer-Rathje et al. (2009); Shah and Ward (2003); Smith et al. (2003); Spithoven (2001)</p> <p>Anand and Kodali (2010); Angelis and Fernandes (2012); Barton and Delbridge (2006); Birdi et al. (2008); Brkic and Tomic (2016); Conti et al. (2006); de Menezes et al. (2010); Delbridge et al. (2000); Doolen et al. (2008); Dubey and Singh (2015); Friedrich et al. (2016); Furlan et al. (2011); Hiltrop (1992); Jones et al. (2013); Khalaf et al. (2011); Kim et al. (2002); MacDuffie (1995); Marksberry (2010); Martínez-Jurado et al. (2013; 2014); Niepce and Molleman (1998); Pakdil and Leonard (2014); Pil and MacDuffie (1995); Procter and Radnor (2014); Rodríguez et al. (2016); Shaiken et al. (1997); Tortella and Fogliatto (2014); Wickramasinghe and Wickramasinghe (2016); Womack et al. (1990)</p>

Trade unions	Ahmed et al. (1991); Clardy (1999); Delery (1999); Dong and Bae (2005); Lee (2003); Lee (2004); Lewchuck et al. (2001); Martínez-Jurado et al. (2014); Shah and Ward (2003)
Knowledgeable workforce and participative management	Bonavía and Marin-García (2011); de Koeijer (2014); Drew et al. (2004); Emiliani (2007a); Emiliani (2007b); Emiliani (2008a); Emiliani (2008b); Gollan et al. (2015); Gupta et al. (2013); Jabbour et al. (2013); Jürgens and Krzywdzinski (2013); Kim et al. (2002); Liker and Hoseus (2010); Lindsay et al. (2014); Longoni and Cagliano (2015); Meiling et al. (2012); Morrison (2015); Nepal et al. (2011); Niepce and Molleman, (1996); Paez et al. (2004); Rane et al. (2016); Sawhney and Chason (2005); Scherrer-Rathje et al. (2009); Shadur et al. (1995); Sohal and Egglestone (1994); Tortella et al. (2015); Wickramasinghe and Wickramasinghe, (2016); Yang and Yang (2013)

1.3.1. The role of socio-cultural factors in the implementation and consolidation of lean production

The production system of Toyota, lean production, enjoys a great deal of attention on behalf of managers and is implemented worldwide. However, notable advancements are first achieved and exploited in Japan. It is only then when these new principles are transferred to different parts of the world (Saruta, 2006). This results in a perplexing situation provided that “foreign affiliates of Toyota belong to the same manufacturing family and the same set of human resources practices are utilized” (Liker, 2004, p. 4.). Following Engström et al. (1996), the resolution of the aforementioned puzzle can be

found in taking an investigative approach and devote research scrutiny to socio-cultural factors of lean production.

As a socio-technical system (Shah and Ward, 2003), lean production regards people as one of the system's core resources. Therefore, the central role of employees' acceptance or rejection of the production model is given recognition (Spithoven, 2001). However, cultural differences play a role in this regard (Moreno, 1999). For instance in Japan, employees' attitude related to quality of work life (QWL) differs from other parts of the world (Niepce and Molleman, 1996). Japanese workers' need for social relations is considerably more intense than the desire for personal achievement and independence. On the contrary, there is a clear preference in Western countries for personal growth needs which exceeds the need for social relationships. In these countries, the employees favor autonomy rather than the need to belong to a group (Niepce and Molleman, 1998).

In this light, Oliver et al. (1994) analyzed 18 manufacturing firms in different socio-cultural settings. Nine of the plants investigated were located in Japan with the rest stemming from the United Kingdom. The investigation revealed that in terms of quality performance, all of the significantly higher achieving companies originated from the Japanese subset. Oliver et al. (1996) tested the same assumption on a bigger sample and with an expanded cultural context so that the subset comprised 71 manufacturing firms in eight countries. As a result of the analysis, the suppositions of the original research were further reinforced, lending support to the socio-cultural contingent nature of lean production. In relation with the socio-cultural context of lean production and human resources management, Lowe et al. (1997) managed to come to the same conclusion as afore articles by scrutinizing operational performance outcomes in companies with a Japanese cultural background and comparing the results with their European and North American counterparts. Their research also reveal an inconsistency,

as they highlight that human resources management practices do not seem to play a role in terms of performance outcomes in case of the different cultural backgrounds. In a similar setting, the introduction of lean production into Egyptian manufacturing firms was also observed to boost operational performance (Salaheldin, 2005).

In a study about quality commitment of employees in a comparative study of Korean automobile companies, reward factors were disregarded as a motivator (Lee and Peccei, 2008). This is contradictory to well-established theories about reward systems (Lincoln and Kalleberg, 1990). However, this phenomenon can be attributed to cultural differences in lean production, since the Korean organizational culture is closer to the Japanese one (Lee and Peccei, 2008), where the need for personal achievement is less dominant (Niepce and Molleman, 1998).

The implementation of lean production entails a fundamental change in the organizational structure of companies (Scherrer-Rathje et al., 2009). Employees' ability to adapt to the freshly introduced circumstances is dependent on certain socio-cultural factors. In this process, the capacities of management to shift to new standards and workers' ability to protect their interests have to be taken into account (Lewchuck et al., 2001). Therefore, the final outcome of the implementation of lean production has to be comprehended as a result of the contestation between management and labor (Shah and Ward, 2003). In connection with human resources management in lean production, the above described phenomenon is often referred to as democratic Taylorism (Adler, 1993). As a conclusion, the transference of the Japanese lean production practices depends to a great extent on socio-cultural aspects of the host nation. This includes historical and environmental context, such as long working hours, lifetime employment and seniority-based wage (James and Jones, 2014).

1.3.2. The effect of work organization in the implementation and consolidation of lean production

One aspect that has attracted an incremented amount of research scrutiny is the impact of work organization on the implementation of lean production. This section is devoted to the analysis of studies, which focus on this phenomenon. The implementation of lean production involves work standardization and routine tasks (Netland, 2013). As working conditions affect the whole spectrum of employees, it is therefore of interest to study these factors (Friedrich et al., 2016).

Indeed, the involvement of certain practices related to work organization in the implementation of lean production is preferred due to its effects to strengthen operational performance (Rodríguez et al., 2016). The implementation process of the model of lean production is often facilitated by intensive training programs (Smith et al., 2003). In addition, the role of teams and team leaders (Marksberry, 2010) as well as team-based reward systems seem to have a positive impact on the overall performance of the company (Dubey and Singh, 2015). This is attributed to the nature of goal setting which contributes to employees' attitude toward coming into possession of the necessary set of skills for their job (Wickramasinghe and Wickramasinghe, 2016). In addition, it is a feasible option to allocate employees into teams with their own responsibilities and giving them the freedom to allocate work among team members, rather than having everyone work as individuals (de Menezes et al., 2010). In this regard, Procter and Radnor (2014) present somehow controversial results about lean teams. They find that team performance is largely context contingent. In their study they argue that lean teams faced an overwhelming pressure and thus experienced difficulties in reaching their targets due to the imposition of meeting targets reduced the time available to take part in problem-solving improvement activities. Therefore, team targets

had to be adjusted and they called for a better comprehension of the role of teams in lean production. They argue that lean and how it interacts with the environment should be better understood. In the face of this, Delbridge et al. (2000) note that team work is an essential component of any lean work organization (Womack et al., 1990). Especially so, since, high-involvement work practices form a central part of lean production (MacDuffie, 1995). Team work is considered to be a productive element of lean production, especially if proper human resources management support is provided (Pil and MacDuffie, 1996). However, it is uncertain whether or not teams should be dealt with as a unitary concept (Shaiken et al., 1997). It seems that the role of the individual members of a team should be divided into at least two categories based on the responsibilities the members take: team leaders and team members (Delbridge et al., 2000).

Similarly, a large degree of vertical and horizontal communication in terms of feedback (Dubey and Singh, 2015) can positively affect the results which a worker might attain (Moyano-Fuentes and Sacristán-Díaz, 2012). Effective feedback is an important part of establishing best-practices (Niepce and Molleman, 1998). In this light Brkic and Tomic (2016) highlighted the role of communication that could have an impact on the work force and make them more committed to the establishment of a lean environment. Communication, especially with the shop-floor seems to be a very important feature of the work organization in a lean environment, especially in the case of the senior and middle-management with the shop floor (Martínez-Jurado et al., 2014).

Employee empowerment via the use of human resources management related tools plays an important role in this regard (Jones et al., 2013). The devolution of responsibilities to work teams (Khalaf et al., 2011) with team-based supervision (Barton and Delbridge, 2006) is required to ensure effective implementation and organizational

change (de Mendez et al., 2010). Birdi et al. (2008) reinforce the assumption that work organization practices, such as employee empowerment align well together with lean production practices. Nonetheless, a lack of significant results undermines these results, but there are a large number of positive connections between lean production and human resources and their management. In addition, the proposition that the effectiveness of lean production operational practices is work organization dependent is given evidence by Anand and Kodali (2010).

In general, lean production brings about a change with respect to work organization that is subject to controversy (Moyano-Fuentes and Sacristán-Díaz, 2012). On the one hand, monotonous working conditions (Schouteten and Benders, 2004) can lead to increased employee dissatisfaction (Lindsay et al., 2014). Notwithstanding, Conti et al. (2006) claim that lean production is not inherently associated with an elevated level of stress but it is merely a consequence of management decisions. To sum up, traditional human resources management tools and practices should show a trend towards the adaption to lean production so that the beneficiary effects associated with it can be harnessed (Hiltrop, 1992).

1.3.3. The impact of trade unions in the implementation and consolidation of lean production

The presence of trade unions is often regarded as a barrier to lean production implementation. Any progress towards lean production becomes substantially difficult in companies with unionized workforce. This is due to the fact that work organization related negotiation processes usually take time and unions are often - but not always - a source of resistance to change (Shah and Ward, 2003). In the face of this, Lewchuk et al. (2001) describes lean production as a result of the capacity of the management to shift to

new standards and unions ability to promote the interest of employees and resist change. The resistance may manifest in strikes. Therefore, the importance of labor-management negotiation in constraining and shaping corporate restructuring strategies is highlighted when implementing lean production. In this light, Lee (2004) found evidence for a competing trade-off between trade unions and company goals. In this case, the promotion of the trade union's interest was so effective that it negatively affected the achievement of company goals. Lee (2003) further reinforces the previous statement via an example from the Korean automotive industry. He demonstrates that trade unions possess the ability to cause a direct impact on lean production implementation. This is a result of the specification of relationship between the trade unions and management. More specifically, the power of the manifestation of workers' ability to promote their interest, i.e. strikes, can exert an opposite reaction with respect to the implementation of lean production. This occurs as a consequence of workers' dissatisfaction due to fatigue and monotonous work.

In other cases, Kim and Bae (2005) analyzed two companies, one of them unionized (LG Electronics) and the other non-unionized (Samsung SDI). Both companies were highly sophisticated in their HRM practices. Samsung implemented lean principles, LG not. It was found that the adoption of high performance work organizations (HPWO) was highly dependent upon trade union representatives. Therefore, it is pivotal to know the state of unionization of a plant prior to making the decision about the implementation of lean production (Martínez-Jurado et al., 2014). Similarly, Delery (1999) accounts the slow progress of implementation of lean production in the US and European automobile industry for the presence of trade unions. It, however, is noted that trade unions cannot be fully made responsible for the slow-moving advance. Other factors, such as government barriers play a role as well. This

assumption is reinforced by Shah and Ward (2003) and Ahmed et al. (1991) who found no support for the supposition of the adverse effects of unionization.

1.3.4. The influence of knowledgeable workforce and participative management on lean production implementation and consolidation

It is argued by Paez et al. (2004) that the implementation of lean production produces a fundamental alteration in the production system model. Thus, there is a need for a concurrent optimization of not just the technological systems but a considerable amount of attention must be paid to address people-related aspects as well (Bonavía and Marin-García, 2011). The success of the transformation process, however, does not equally favor all companies, due to the human element related complexities associated with the process of change (Scherrer-Rathje et al., 2009). Owing to the knowledge-intensive nature of lean production, workforce not only needs to possess a great variety of skills, but their responsiveness to change should also be taken into account (Drew et al., 2004). In addition, the commitment of top management is crucial during the whole process of the implementation process (Rafique et al., 2016), since the implementation of lean production also includes the flattening of the management structure due to the introduction of a TQM regime (Sohal and Egglestone, 1994; Nepal et al., 2011). Indeed, Shadur et al. (1995) added that prior to the implementation of lean production, there is a necessity to address people-related aspects. The acquisition of the proper skills has been highlighted by many researchers. For instance, Baril et al. (2016) and Meiling et al., (2012) argue that continuous improvement can be beneficial in terms of process performance and its effects start showing after a short period of time. Skilled workforce demonstrated that it could prove to be an asset to provoke a series of beneficial impact on the company. Morrison (2015) argues that knowledgeable workers may come up with in situ solutions for completing assignments even if the company is short of resources.

Line managers have a crucial role in the implementation process of lean production. Yet, this is often neglected and even researchers tend to focus on role of the management. However, a solution for certain barriers, such as employees' resistance to change could be lifted. This would be achieved by the devolution of responsibilities to line managers (Gollan et al., 2015). On this ground, Gupta et al. (2013) argue that the management of the company can formulate strategy to build favorable organizational culture and develop human resource to bring about required changes which are essential for the implementation of lean production. This means that human resource management and the aspects associated with it is a main driving factor in changing the mindset of the workers and forming them so that they become more receptive for complex changes. Indeed, attitude formation of the employees and the recruitment of the adequate, already receptive worker might be a key factor in the early phases of lean production implementation (Jabbour et al., 2013; Jürgens and Krzywdzinski, 2013).

According to Yang and Yang (2013), a successful implementation depends on the company's ability to integrate the "hard side" of lean production with its "soft side". That is, the consideration of technical aspects only does not contribute to the achievement of results. In order to attain a successful lean production implementation one needs to address people-related phenomena in this regard as well, which have a remarkable significance during the transition process toward lean production (Sawhney and Chason 2005). Sometimes, however, the text book type lean production implementation can lead to employee dissatisfaction and can negatively impact the lean transformation as a whole (Lindsay et al., 2014). It is therefore important that managers opt for an enabling human resources management and foster employee satisfaction for improved performance outcomes (de Koeijer, 2014) and better well-being (Longoni et al., 2013). Similarly, Niepce and Molleman (1996) signal that Japanese employees'

attitude related to quality of work life may be different. Under the new circumstances that the implementation of lean production brings about, workers are rather rewarded on the basis of the contribution they have made for the company (Wickramasinghe and Wickramasinghe, 2016). This variable pay program can be obstructive at first but then they tend to pay off and turn into a means of a facilitating factor (Karlsson and Ahlström, 1995). In general, the remuneration system seems to be an important aspect that managers should use carefully.

1.4. Conclusions

Present paper provides a new classification of the literature concerning the role of human resources and their management in the implementation and consolidation process of lean production via a systematic literature review. The article builds on a sample of 74 articles, which handle the question of lean production and human resources in the same theoretical context. In this light, the evaluation of the available scientific literature has enabled the identification of four lines of research: 1) Socio-cultural factors, 2) Work organization, 3) Trade unions, and 4) Knowledgeable workforce and participative management. The proposed classification can be regarded a significant contribution towards the ability of academics and practitioners to comprehend the impact of human resources and their management in the implementation and consolidation process of lean production.

The classification of the literature into lines of research also adds to the theoretical progress, which aims to enhance researchers' comprehension concerning the role of human resources and their management in the implementation and consolidation process of lean production. In particular, the four proposed lines of research enables the deduction of progress by research, facilitate the work of new researchers who want to

delve into this area, reveal the contradictions and inconsistencies existent in the literature. This paper also permits researchers to find aspects, which have been scrutinized with respect to the human resources and their management in the context of lean production. That being said, aforementioned research area is divisible into four major lines of research. On the one hand, socio-cultural factors and trade unions pertain to the external environment of the company, that is, the firm has little control on these aspects. On the other hand, work organization as well as knowledgeable workforce and participative management are related to the internal environment of the company, where it has a higher degree of maneuvering ability. Therefore, depending on the profile, area of specialization and focus of interest of the researcher, it will be possible to identify new research questions that require empirical attention.

So, the classification enables the detection of gaps, that is, areas that have yet to be subject to further research. One gap pertains to the relationship between lean production and human resources and their management in the implementation and consolidation phase of lean production. More specifically, a number of authors have signaled that the human element is an essential aspect of lean production (e.g. Emiliani, 2007a, b). Yet, there is no consensus for how work organization affects the outcome of lean transformation on the course of its implementation and consolidation. For this reason, it may be beneficial to adopt a multidimensional point of view and devise an empirical work for future analyses in this regard. The importance for an integrated perspective of human resources management and lean production has been recently discussed by Rodríguez et al. (2016). In order to be successful, lean production implementation requires organizations to apply lean principles in all organizational functions (Pakdil and Leonard, 2014).

Evidence was found that could lend support for the assumption that the implementation of lean production combined with human resource practices positively affected operational performance (Gollan et al., 2014). Since latter variable is regarded as a feasible indicator to measure the successfulness of the transformation process (Dora et al., 2013), the integration of human resources and their management into the bundle of lean production might be a desirable step towards a better understanding about lean production and human resources and how these two contribute to an incremented chance of a successful transformation. Yet, with the notable example of Marin–García et al. (2011), very few studies have endeavored to take such a holistic approach.

With respect to the role of trade unions and their effect on the implementation and consolidation process of lean production, it is somewhat interesting that the empirical evidence pertaining to this field is subject to contradiction. Dong and Bae (2005) linked high performance work organizations to the presence of trade unions, while Shah and Ward (2003) could not corroborate the assumption that trade unions would negatively impact the performance of lean companies. For this reason, future studies should be carried out to put an end to this debate.

Lean production is a management system that has spread from Japan, where it was first used, to various parts of the world. With the propagation of globalization, more and more countries are expected to embark upon the principles of lean production and opt for its implementation due to the benefits associated with it. It is therefore pivotal that managers are aware of the impact that socio-cultural factors have on lean production. With respect to the successfulness of the lean transformation, this particular attention can be crucial, since the Japanese working culture might be significantly different from the cultural context of the country in which lean production is about to be introduced (Engström et al., 1996). Therefore, thorough investigations should be

conducted to shed more light on the socio-cultural contingency of lean production. Especially so, since different management philosophies might have distinct implications depending on the national culture where the new system is put into place (Hofstede, 1983). Thus, lean production might be appropriate in one set of nations whereas its implementation can bear less suitability for the other. For this reason, more empirical evidence is necessary that provides a deeper understanding about the relationship between the socio-cultural context of lean production and the successful result of its implementation.

Placing the focus on the scantiness of studies that analyze the causes of failures with respect to the implementation of lean production, Alagaraja (2014) suggests that factors leading to an abortive implementation of the management system should receive more scrutiny. Indeed, the literature has an almost exclusive focal point that is devoted to the investigation of factors that address the aspects that result in a favorable outcome. In the same time, the bibliography lacks the aforementioned investigative attention. Therefore, future lines of scholarly research should emphasize the causes that result in the lean transformation process to fail so that managers can attain the ability to study and learn from these failures and potentially gain the capability to prevent those circumstances from reoccurring.

There are two main aspects on the subject of the fourth line of research, knowledgeable workforce and participative management that need more research scrutiny. Firstly, it should be made clear how the role of improvement groups influences employee participation and empowerment in the implementation and consolidation process of lean production. Then, evidence is required to acquire an insight into how afore process can be enhanced by the presence of more sophisticated incentive systems that take into account the positive contribution of the workers. Similarly, with respect to

the failed instances of lean production implementation, it could prove to be useful to prepare an investigative study concerning the role of human resources management in said process regarding the sectors of the industry where it has had less success. More specifically, it could be investigated how the success ratio in aforementioned sectors react in the presence of an increased level of human resources management.

Present paper has vital implications for managers who wish to study the impact of human resources and their management in their respective companies that have recently commenced or have already made the next step in the implementation of lean production. More specifically, it may provide practitioners with more extensive knowledge on the subject of the human element in the implementation and consolidation of lean production. This can facilitate their decision-making and count towards the factors that results in a successful outcome with respect to the implementation of lean production. These factors are divided into two categories based on the ability of the company to have an influence on them. Work organization as well as knowledgeable workforce and participative management pertain to the group where the firm is capable to manage, whereas trade unions and socio-cultural factors fall into the category of external factors where the company has only limited ability to maneuver.

The limitations of this paper have to be recognized. One such limitation pertains to the methodological approach that was used in this paper. More specifically, while the methodology followed an inclusive conduct and the article sample is considered to be free of biases, it is impossible to completely rule out this sort of apprehension. Similarly, concerns may arise on the subject of the generalizability of the results, since the majority of the articles deal with the situation in the manufacturing industry where lean production is more prevalent, thus other sectors, such as health care and services are not sufficiently represented.

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Annex 1.I. Detailed analysis of the key contribution of the analyzed papers and line of research to which each of the articles pertain

Author(s)	Key contribution	Line(s) of research*
Anand and Kodali (2010)	The results of a mathematical model highlight the role of internal and external stakeholders of the organization while implementing lean production.	2
Angelis and Fernandes (2012)	This article states that in order to be successful in lean setting, companies need to pursue continuous improvement that is achieved by problem solving ability, employee involvement and improvement programs.	2
Angelis et al. (2011)	This paper corroborates the idea that successful lean production implementation necessitates a committed workforce. It is showed that lean production does not inherently induce changes in workers' commitment; rather it is up to the management to condition the workforce to be more receptive for the idea of lean production and the changes that he process involves.	4
Ballé et al. (2016)	Operational excellence is different from just the application of lean practices to every process. People are equally important in this process.	4
Barton and	Declares the importance of devolution of	2

Delbridge (2006)	responsibilities to workers, among others, to first-line managers. In addition, the role of team-based supervision is highlighted. This piece of literature also adds to the growing number of evidence that company culture plays a great role in the implementation of new ideas (such as lean production). In this article, this latter is referred to as "macho culture of manufacturing" which is considered to be a barrier to effective implementation of progressive ideas.	
Birdi et al. (2008)	Work organization practices work well together with lean production practices. Their explicit model was not supported by significant results.	2
Bonavia and Marin-García (2011)	Addresses the need of research interest into the effect of the human variable on the success of lean production (LP).	4
Bonavia and Marin-García (2015)	Cross-functional managers and employee involvement positively affect the strategic alignment of the lean and human resources management with environmental and social aims and aspects.	2, 4
Brkic and Tomic (2016)	The purpose of this paper was to survey which employees' behavior aspects can lead organization to better concepts integration and how lean principles enhances employee's performance.	2
Clardy (1999)	Lean production was a result of the conjunction of favorable socio-cultural circumstances in Japan that is	3

	also connected to the exile of trade unions. This brought a considerable amount of increase in quality and performance in Japan but only slow progress in other regions due to mixing HRM practices with local aspects.	
Conti et al. (2006)	The management system of lean production should not considered to be inherently stressful. The adverse effects of the implementation arise as a decision of the management in designing lean production systems.	2
de Koeijer (2014)	Enabling human resources management fosters employee well-being (happiness, health and trusting relationships) and improves organizational performance.	4
de Menezes et al. (2010)	This research show evidence for the supposition that early integration operations and human resources management pays off in the following stages and calls for such thinking.	2
Delbridge et al. (2000)	Team work is considered to be a productive element of lean production but proper HRM support should be provided However, team members' responsibilities should be made distinct and categorized into two groups: team leaders and team members.	2
Delery (1999)	In an overview about the situation of lean production, a rapid movement was detected towards the adoption of lean production in the European automobile industry.	3

	This process, however, is partial. Trade unions and government barriers might have been responsible for the slow progress in the US, although their impact is not universal.	
Dong-One and Bae (2005)	Analyzed two companies, one of them unionized and the other non-unionized. Both with highly sophisticated in their HRM practices. Evidence shows a high degree of dependency upon top management and union/employee representatives in case of lean production implementation.	3
Doolen et al. (2008)	It was found that team work and management involvement play a great role in achieving a successful outcome related to lean production implementation.	2
Dubey and Singh (2015)	Human resources management is a key driver of successful lean implementation, in which communication should flow both vertically and horizontally and facilitates the continuous flow of feedback between employees and the organization.	2
Emiliani (2007a)	Aims to assist managers to face and tackle the challenges that are associated with lean production implementation by highlighting the principle respect for people and stating that managers should take into account people related aspects when making decisions.	4
Emiliani (2007b)	Offers advice to managers on the history of lean production and the principles of respect for people and	4

	continuous improvement play a role in shaping the decision-making.	
Emiliani (2008a)	Provides new ways for senior managers by linking lean principles and tools to leadership behaviors.	4
Emiliani (2008b)	Deals with problems related to the sustainability of lean production. It is highlighted that the principle respect for people is often missing and advises managers to incorporate this idea into their decision-making.	4
Farris et al. (2009)	Provide a greater focus on the „softer” side of the lean production implementation and describes that human resource practices, such as employee participation in continuous improvement programs, cross-functional teams, employee training, and job rotation systems are the backbone of the transformation process.	2
Friedrich et al. (2016)	The article deals with the role of team learning in a lean environment. The shop floor level of a lean company work is mostly standardized; still, work complexity positively affects team learning and impacts team proactivity.	2
Furlan et al. (2011)	Investigation of the role of human resources (team work, role of management, training, organizational structure, role of shop floor engineers, problem solving, continuous improvement) as an enhancer of the complementarity between two lean bundles, JIT	2

	and TQM.	
Gollan et al. (2015)	Responsibilities pertaining to human resources management should be devolved to ensure effective implementation of organizational change related to lean production.	4
Gupta et al. (2013)	Employee motivation, employee expertise and skills, multitasking, employee accountability, employee attrition allow employees to contribute to the accomplishment of the organization's strategic goals. Based on this model, management can formulate strategy to build favorable organizational culture and develop human resource to bring about required changes for lean manufacturing scenario.	4
Hiltrop (1992)	Traditional human resources management tools and practices should show a trend towards the adaption to lean production so that the beneficiary effects associated with it can be harnessed	2
Jabbour et al. (2013)	Link recruitment, training, performance evaluation, rewards, benefits and lean production and emphasizes that these be treated under one model.	4
James and Jones (2014)	Success of the implementation of lean production depends on the socio-cultural, historical and environmental context of the host nations in which the transformation takes place. This requires a multi-dimensional point of view related to human resources.	1

Jones et al. (2013)	This study identified and emphasized that the role of human resource management is crucial in case of employee empowerment.	2
Jürgens and Krzywdzinski (2013)	Connects human resources management and lean production and notes that due to cultural aspects (different countries) the standardization of human resources management is problematic and that this can result in a failed transformation.	4
Karlsson and Ahlström (1995)	Provides an explanation of the role of remuneration system in the implementation phase of lean production in a mechanical manufacturing firm. The remuneration system can be both facilitating and obstructing depending on the time that has elapsed from the initial implementation.	2
Khalaf et al. (2011)	JIT and TQM enhance labor efficiency, because JIT facilitate employee empowerment while in the same time TQM contributes to increase productivity by reducing downtimes and carrying out planned maintenance. This is achieved by continuous improvement that bestows employees upon the necessary skills	2
Kim et al. (2002)	Total involvement includes personnel from each level of the organization and it is suggested that they must share the vision of lean production. Adequate training is also important (e.g. via cellular manufacturing).	2, 4

Laureani and Antony (2010)	Improvements were observed in the human resources area (lower turnover and higher employee satisfaction) of the firm after the implementation of lean production.	2
Lee (2003)	Demonstration that trade unions have the ability to cause a direct impact on the company's adoption of lean production in Korea due to the specification of labor relations.	3
Lee (2004)	Identified a competing commitment between trade unions and company goals. This had implications for companies that set the introduction of lean production as a goal for the company.	3
Lee and Peccei (2008)	Evidence that employees' quality commitment does not depend on reward factors in Korea. This was identified as an important difference between Western and Asian lean production firms.	1
Lewchuck et al. (2001)	It is highlighted that socio-cultural aspects affect companies' ability for the attainment of a successful lean production implementation and is largely dependent on management's capacity to shift to new standards and workers' ability to protect their interests.	1
Liker and Hoseus (2010)	Knowledgeable workforce has a crucial importance even in state-of-the-art technology use, because the system will always be imperfect and it is up to people to identify problems and make improvements.	4

Lindsay et al. (2014)	Employees questioned management's assumption about the benefits of lean productions given the limited opportunities for development that contributed to work intensification.	4
Longoni and Cagliano (2015)	Cross-functional executive involvement and worker involvement positively impact lean practices with environmental and social goals and practices and the sustainability of the transformation.	4
Longoni et al. (2013)	In firms where the lean production implementation was not supported by the human resources management, the number of concerns pertaining to health and safety performance was significantly higher.	2
Lowe et al. (1997)	A repeated study based on Oliver et al. (1996) showed further evidence for the socio-cultural dependency of lean production via the inclusion of firms from Japan, and the USA and Europe.	1
Marin-García et al. (2011)	This research links human resources (empowerment, training, team-work, remuneration and communication) to lean production in sheltered work centers.	2
Marksberry (2010)	Comes up with evidence that team leaders play a crucial role in the implementation of lean production, and therefore it is very important to train knowledgeable team leaders.	2
Martínez-Jurado et	Case study about the role of human resources in lean	2

al. (2013)	production. Factors: training, communication, rewards, job design and work, organization and employment of an external change agent (a priori the implementation).	
Martínez-Jurado et al. (2014)	Case study about the role of human resources management in the transition process to lean production in the aeronautics industry. In the pre-adoption phase the main emphasis should lay on the management-trade union relationship. Later stages are focused on: training, communication, rewards, job design, and work organization.	2, 3
Meiling et al. (2012)	Continuous improvement provides an insight into the debate in lean production about human resources by empirically clarifying that the continuous improvement must emerge and develop in the same time with the technical and people-related aspects.	4
Moreno (1999)	A comparative study, which revolves around the similarities and possibilities of convergence between lean production and the model of production of Volvo in Sweden. Points of view are analyzed related to work organization in the different cultural settings.	1
Morrison (2015)	The role of problem solving skills and the impact of knowledgeable workers in a resource deprived lean environment make it possible to overcome obstacles and work with what is available.	4
Nepal et al. (2011)	One of the four strategies for the implementation	4

	process was related to increasing the number of full time managers to be overseen by a senior project management. Thus, HR managers were kept updated and that lead to a successful transformation to lean production	
Niepce and Molleman (1996)	In Japan lean production plants, cultural values, such as individualism versus collectivism play a role in this regard and the need for social relations seems to be more intense than the need for personal achievement and independence. Conversely in Western countries, personal growth needs often exceed the need for social relationships.	1, 4
Niepce and Molleman (1998)	As processes are centralized in lean production, in terms of work organizations, a state-of-the-art feedback is utilized to correct work methods and to come up with more sophisticated best practices.	1, 2
Oliver et al. (1994)	Japanese and other lean production plants were compared in terms of quality and performance. It was determined that Japanese firms performed significantly better.	1
Oliver et al. (1996)	In the UK, Japanese-style work teams are seen as one of the key elements of the lean production model. These teams involve relatively small groups of employees working together under the control of a team leader, typically taking on responsibility for	1

	activities which may previously have been the prerogative of specialist support departments.	
Pakdil and Leonard (2014)	Lists human resources as a key element of lean production. To be successful, lean production implementation demands organizations to apply lean principles in all organizational functions. Turnover, absenteeism, feedback, team work, employee involvement, problem solving should be given attention.	2
Pont et al. (2009)	Human resources management was included in the bundle of lean production (with JIT and TQM) where these three variables have a self-reinforcing effect. Human resources is an indivisible part of lean production.	2
Portioli and Tatardini (2008)	183 Italian manufacturing plants were investigated with respect to competition. It is shown that lean production provides European firm with a competitive edge through conformity, quality and delivery reliability.	1
Procter and Radnor (2014)	In their study they argue that lean teams faced an overwhelming pressure and thus faced difficulties in reaching their targets. Therefore, team targets had to be adjusted. Thus, team performance is largely context contingent	2
Rane et al. (2016)	In case of resource shortages, skilled workforce finds a	4

	way to discover workarounds and still complete the task. In case of the implementation of lean production, employee and management involvement are important factors.	
Rodríguez et al. (2016)	The implementation of lean production combined with human resources management related to work organization practices positively impacts perceived job autonomy, job satisfaction, and operational performance.	2
Salaheldin (2005)	Scrutinized 200 manufacturing firms in Egypt with the result that lean production enhances operational performance.	1
Shah and Ward (2003)	This research did not find any significant links that would provide evidence for the assumption that trade unions had an effect on the implementation of lean production.	3
Smith et al. (2003)	Investigated the situation in private companies in Australia on a sample that contained hundreds of firms that have adopted new managerial systems, such as lean production. Training was found to be a driving factor of their implementation.	1
Sohal and Egglestone (1994)	The implementation of lean production causes structural changes in organizations that flattening the management structure.	4
Spithoven (2001)	The article investigates the situation of Dutch	1

	production plants in the period when these production units switched from traditional mass production to lean production. It is explained that on behalf of the workers, acceptance or rejection of the model depends on the time when it is introduced.	
Taj and Morosan (2011)	Remuneration, job security, team, turnover and training have a significant and positive impact on certain lean aspects (flow, flexibility and quality.	2
Tortella and Fogliatto (2014)	Claim that there is a need to address behavioral aspects of people in the implementation process. HR practices at the individual, team and organization level play a key role in the implementation process (communication, motivation, team work, employee involvement, and training).	2
Tortella et al. (2015)	Human resources management plays a crucial and leads to a more effective lean production implementation. Nine out of the ten top barriers to the transformation are people-related, including poor communication and employees' resistance to change	4
Wickramasinghe and Wickramasinghe (2016)	Evidence for the positive impact of remuneration (variable pay plans) on job performance adopted for shop-floor workers engaged in lean production firms.	2, 4
Wong and Wong (2014)	Critical barriers to lean production implementation related human resource management (e.g., employee	2

	training, management support) and the interactions among these factors are important and should be examined The study supported the proposition that human resource factors and their antecedents directly impact the success of operations management practices.	
Yand and Yang (2013)	Contribution to a holistic view about lean production (hard and soft sides of the implementation) by proposing an integrated model that comprises TPM and TQM with human resources management.	4

* Lines of research are: 1: Socio-cultural factors; 2: Work organization; 3) Trade unions;

4) Knowledgeable workforce and participative management

CHAPTER 2.

LEAN PRODUCTION, WORKFORCE DEVELOPMENT AND OPERATIONAL PERFORMANCE

2.1. Introduction

The industrial scene has faced heightened challenges due to the increase in global competition and has been the subject of radical change over the last three decades. Not only market conditions have been in constant motion, but the progress in technology has enabled consumer needs to change at an unparalleled rate. Consequently, this concept compelled manufacturing firms to adapt manufacturing approaches, which are more oriented toward customer needs (Hall, 1987). As a consequence of the Toyota Motors' enduring success (also referred to as the “*Toyota Miracle*”) owing to the consequence of taking use of a variety of practices related to lean production (Womack et al., 1990), this sociotechnical system (Moyano-Fuentes and Sacristán-Díaz, 2012) has received a great deal of research interest. The underlying point of this managerial toolset comprises the principle of cost reduction via driving out any unnecessary expenses. Thus, the main focus is turned to efficiency (Hines, 2004).

Prior to the 1990s, research interest, in pursuit of achieving better results, mainly focused on the technical aspects of the implementation of lean production (Bonavía and Marin-García, 2011), but this kind of attention later shifted to address people-related phenomena (Martínez-Jurado et al., 2013). In the cultural change, which is a result of the implementation of lean production, the pivotal role of people and workforce is often highlighted (Bonavía and Marin-García, 2011; Martínez-Jurado et al., 2013). Several aspects of human resources have been the subjects of research interest during the period

of implementation of lean production. Such include managerial and employee-related commitment to the implementation (Harrison and Storey, 1996), job design (de Treville and Antonakis, 2006). In case of work systems, the implementation of lean production comes with increased job variety (Schonberger, 1986), increases workers' autonomy (Vidal, 2007) and induces changes in work organization (Biazzo and Pannizzolo, 2000) and motivation (Canós-Darós, 2013), generates an augmented use of teamwork in problem-solving and causes a higher variety of tasks performed while a greater number of workers' suggestions are implemented (Forza, 1996) and the role of supervisors is increased (Lowe, 1993). It was suggested that practices related to workforce development should be scrutinized as a bundle rather than individual practices (Jiang et al., 2012a), as the synergetic effects can add up (Jiang et al., 2012b). Although the idea that workforce development has a direct (not just implicit) impact on the lean production – operational performance relationship may seem intuitive, such a result has not yet been reported.

There has been a spate of research that has sought to test whether lean production increases operational performance (Shah and Ward, 2003; Vázquez et al., 2007). However, the role of the workforce development has not been analyzed in this relation. Therefore, this study aims to cover this gap by means of scrutinizing the impact of workforce development on the lean production – operational performance relationship. Operational performance is a viable measure for assessing the immediate effects of workforce development via analyzing operational outcomes. In order to provide an answer to the research question, present paper is structured into five parts. The introduction is followed by a theoretical review and by the description of the hypotheses. Section three covers the research methodology, while section four

underlines the results of the study. The conclusions and implications are outlined in the fifth section.

2.2. Research background and hypotheses

2.2.1. Lean production

The term “*lean production*” was first used in the Japanese manufacturing industry and the term itself was devised by Krafcik (1988). It refers to a set of integrated socio-technical principles with the aim of minimizing internal and external system variability to the lowest extent (Shah and Ward 2007); while simultaneously value is being created (Murman et al. 2002). In addition, maximum efficiency attained by driving out causes of inflexibilities which in turn lead to an improvement in quality, per unit manufacturing costs and customer lead time, that is, to better operational performance (Womack and Jones 1996). There is an understanding among scholars about the “high-performing” lean practices (Narasimhan et al., 2006; Furlan et al., 2011; Bortolotti et al., 2015; Zirar et al., 2015). Regarding the theoretical background of lean production, Moyano-Fuentes and Sacristán-Díaz (2012) developed a model that allows the researcher to understand lean production to a greater extent. Based on all the above, it is assumed that the most characteristic practices of lean production can be grabbed in the following classification:

1. Just-in-time production (JIT)
2. Cellular manufacturing
3. Total productive maintenance (TPM)
4. Total quality management (TQM)

Following Moyano-Fuentes et al. (2012), lean production can be described as a set of philosophical tools, which is in a state of continuous evolution and encompasses all levels of the organization (Womack and Jones 1996). The practices of lean production should be allowed to be taken a look at only from a multidimensional point of view, whereby the building blocks of the philosophy cannot be looked at separately, but rather as a whole (Shah and Ward, 2007).

2.2.2. The role of workforce development in lean production

Within the framework of lean production, workforce development plays an important part (Sakakibara et al., 1997; Bonavía and Marin-García, 2011). Many researchers lay stress on the role that the appropriate use of the “*human element*” has a remarkable significance during the transition process toward lean production (Sawhney and Chason 2005). Due to the knowledge-intensive nature of lean production, workforce not only needs to possess a great variety of skills, but their responsiveness to change should also be taken into account (Drew et al., 2004). Indeed, Shadur et al. (1995) added that prior to the implementation of lean production, there is a necessity to address several people-related aspects, such as lack of skills required. In order to deal with the issue in concern, workers are required to take part in active skill development programs to obtain the required skills. Owing to Cua et al. (2001), acquisition of information, becoming empowered and involved in operations, that is, active skill development can facilitate the implementation of lean production, while problem-solving skills can come handy in the first few months of the implementation of lean production, during which phase failure is observed the most frequently (Meade et al., 2010). Similarly, the advantageous effects of lean production are unlikely to be achieved unless there is a large degree of

feedback which can positively affect the results which a worker might attain (Moyano-Fuentes and Sacristán-Díaz, 2012).

The following aspects are considered to comprise the practices related to workforce development (Osterman, 1994; Forza, 1996; Power and Sohal, 2000; Cappelli and Neumark, 2001; Narashimhan et al. 2006):

1. Active skill development
2. Highly skilled employees
3. Cross-functional workforce
4. Exchange of opinions and ideas (feedback)
5. Problem-solving abilities
6. Self-directed work teams

2.2.3. Operational performance

Operational performance seems to be a feasible option when one would like to consider the immediate effects of different kind of factors, such as workforce development by scrutinizing operational outcomes. Following Shah and Ward (2003, p. 138.), “manufacturing processes that are faster and more precise with regard to first-time-through quality are also inherently less costly”. Cua et al. (2001) demonstrated that the inclusion of some practices related to workforce development can boost certain practices of lean production (TQM, JIT and TPM), which then results in increased operational performance outcomes due to higher inventory turns, lead-time reduction, and increased quality (McKone et al., 2001).

These items also correspond to the lean concepts of lead time reduction, cost reduction, and conformance quality. Therefore, it is contended that the following aspects relate closely not only in conceptual but also in empirical sense to devising the operational performance (Hall, 1987, Spear and Bowen, 1999; Ross, 2003).

1. Scrap and rework costs
2. Manufacturing cycle time
3. First pass yield
4. Labor productivity
5. Unit manufacturing cost
6. Customer lead time

2.3. Hypotheses

Deming (1982) presumes in his chain reaction model that improvements in performance engender from the impacts of quality, in forms of reduction in waste of materials, labor and machine hours. This bestows a reduction in per unit manufacturing cost, improved productivity, and hence increased performance on the plant. TQM practices increase JIT performance by means of decreasing rework time, while further performance improvements can be attained by problem exposure and more advanced process feedback (Flynn et al., 1995). Cua (2000) laid claim to the importance of information and feedback in case of a JIT production environment, which then contributes to higher returns in operational performance (Salaheldin, 2005). TPM, as a practice of lean production has a positive relationship on operational performance due to higher inventory turns, lead-time reduction, and increased quality (McKone et al., 2001).

Lean production is commonly shown to be associated with improvements in operational performance in the literature (Jabbour et al., 2013), owing to the benefits, which hail from the improvements in labor productivity, quality and lead-time, cycle-time and manufacturing costs (White et al., 1999). As illustrated above, however, the majority of articles have focused on the relationship between the implementation of lean production and the operational performance by considering only one of the integrated management practices of lean production (Shah and Ward 2003). Since then, only a scant number of studies have made an impact in uncovering connections in this regard with lean production as a bundle, being a new research direction (Furlan et al., 2011; Zirar et al. 2015; Bortolotti et al., 2015). This paper seeks evidence contributing to the renewed interest in the study of operational performance with an emphasis on the investigation lean production as a bundle.

Based on the above reasoning, it is expected that high performing manufacturing plants have a higher level of implementation of lean production, thus providing new evidence for such a relationship in new environmental setting. This is reflected in the following hypothesis:

Hypothesis 1. *There is a positive relationship between the implementation of lean production and the operational performance of the company.*

For many companies, the sources of sustainable competitive edge have been observed to be shifting from a techno-economic nature towards providing a greater role to the human factor. The reasons behind this fact are to do with the hardships in imitating capabilities of employee knowledge. Notably, employee participation, empowerment, job redesign, team-based production systems, extensive workforce training are thought to increase the

performance of the company (Pfeffer 1994). In this light, the positive relationship between training and performance has often been emphasized (Pao and Wei, 2002; Jacobs and Washington, 2003). As argued by Bartel (1994), the implementation of personnel training policies contribute to a significant increase in labor productivity, thus have an impact on the operational performance of the company, while it helps maintaining competitive advantage.

In a lean environment, workforce development is directed at improving performance (Bryan, 2006). Therefore, it should contribute to a significant extent to cost reduction, quality improvement, lead-time reduction and aversion of machinery-related breakdowns due regular check-ups performed by skilled and knowledgeable (Shah and Ward, 2003). For this reason, employment training is necessary to advance their capabilities of becoming more perceptive to the acquisition of new skills knowledge (Bonavía and Marin-García, 2011) and thus an increase in performance outcomes via enhanced productivity can be attained (MacDuffie, 1995). Consequently, by means of ongoing training (Bayo-Moriones and Galdón-Sanchez, 2010), workers' abilities are upgraded while opportunities to participate in decision-making are provided (Jiang et al., 2012b), so that talented workers can display their potential contribution to the company (Gerhart, 2007; Boselie, 2010), which can bring about an increase in operational performance (Wafa and Yasin, 1998).

Owing to this train of thought, it is expected that companies with a more developed workforce will have significantly higher outcomes in terms of operational performance, such as stated in the following hypothesis:

Hypothesis 2. *There is a positive relationship between the practices of workforce development and the operational performance of the company.*

The implementation of lean production cannot be brought about unless workers are prepared in advance (Samson et al., 1993). As an instance, job rotation and the introduction of TQM require the plant to possess a skilled and knowledgeable workforce, hence the investment into workforce development is crucial (Osterman 1994). Since the implementation of lean production brings about a fundamental change in the production system model (Paez et al., 2004), there is a need to concurrently optimize the technological and human systems (Bonavía and Marin-García, 2011). The success of the transformation process, however, does not equally favor all companies, due to the complexities associated with it (Scherrer-Rathje et al., 2009). With regard to the human aspects associated with the implementation of lean production, a great deal of studies point out that there has not been enough research into this particular field of study (Bonavía and Marín-García, 2011). In addition, greater stress was put on the technology-related aspect of this process (Bhasin, 2012), outlining that the role of people-related practices should be the subject of a greater deal of attention (Liker and Houses, 2010). Lean production requires the workers to operate on machinery, which depends upon the presence of the corresponding skills. To this end, the flexibility of labor force and workers' continuous improvement through their involvement in suggestion programs and the existence of improvement plans is considered to play a crucial role in the implementation of lean production (Hiltrop, 1992; Osterman, 1994; Power and Sohal, 2000).

It is therefore expected that higher level of implementation of lean production corresponds to a more knowledgeable workforce. This can be formulated in the following hypothesis:

Hypothesis 3. *There is a positive relationship between the degree of implementation of lean production and the degree of workforce development.*

Osterman (1994) and Forza (1996) put forward the idea that lean companies should actively advocate the development of a multi-skilled and flexible workforce with problem-solving skills. Bonavía and Marin-García (2011) analyzed the differences in operational performance among manufacturing plants and found links in favor of supporting their assumption of the existence of a relationship between a higher level of lean production implementation and training as part of the workforce development bundle.

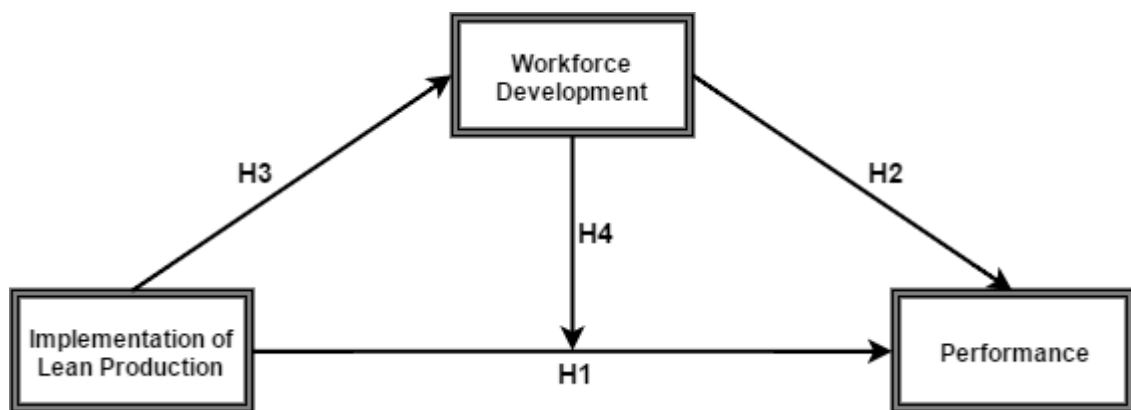
The transition to lean production, however, is a very complex task (Scherrer-Rathje et al., 2009). It implies significant organizational changes which could not be dealt with, should the proper management of the human factor fail to be complied (Martínez-Jurado et al., 2014). Therefore, companies should manage people, commencing in the early stages of lean production implementation (de Treville and Antonakis, 2006). In this light, Olivella et al. (2008) emphasize the importance of training, participation in decision making and worker empowerment along with employee versatility.

A great deal of evidence seems to support the fomenting role of workforce development in the implementation phase of lean production (Dyer and Reeves, 2006; Macduffie, 1995; Wood, 1999), which is seen to contribute to obtaining higher performance outcomes (Dora et al., 2013). Nevertheless, in some cases, no such effect was observed (Flynn et al., 1995; Belekoukias et al., 2014). To this end, it seems that there is an additional factor which influences this kind of relationship. Therefore, workforce development as a moderator is believed to have inferences in the association

between lean production and operational performance and has not yet been studied. Based on the above reasoning, the utilization of the practices of workforce development to a higher degree is considered to contribute to the positive effects of lean production practices in terms of the operational performance of the company, such as stated in the following hypothesis:

Hypothesis 4. *Workforce development moderates the relationship between the degree of implementation of lean production practices and their impact on the operational performance of the company.*

Figure 2.1. The graphical depiction of the hypotheses



2.4. Research methodology

2.4.1. Data collection and sample characteristics

The hypotheses have been tested using data from a sample of manufacturing plants which are first tier suppliers to OEMs (Original Equipment Manufacturers) in the Spanish automotive industry. The population was derived from the database of the Spanish Automotive Equipment and Components Manufacturers Association

(SERNAUTO). This organization lists all equipment and component manufacturers located in Spain. The aim of the association is to carry out and publish periodical reports and statistics with special regard to the conditions of the equipment and component manufacturing industry. For SERNAUTO to comply with their stated objectives, a database was established which contains important knowledge about the structural and organizational attributes of each manufacturing plant in the automobile industry. Upon the authorization of SERNAUTO, aforementioned database can also be used for scientific research purposes and has been routinely used on the corresponding literature (Moyano-Fuentes et al., 2012, Martínez and Perez, 2003). SERNAUTO's database was made up (31th December, 2007) by a total of 216 manufacturing plants belonging to 74 different first tier supplier companies.

Following that CEOs of said companies were contacted, owing to Phillips (1981) who suggested that high ranking informants tend to be more valuable sources of information. CEOs were sent the questionnaire between January and February 2008 by means of e-mail, conventional postal delivery services and internet-based survey. Each questionnaire was accompanied by an explanatory note which highlighted the purpose of the research and encouraged CEOs to participate. After a follow-up process by telephone, 84 questionnaires were attained, each completed to the furthest extent. This corresponds to a response rate of 39% and gives a sample error of +/- 8.54% with a confidence level of 95%. Regarding the nature of respondents, besides CEOs, in ten cases the director of operations, and in 27 cases the director of human resources also took part in completing the questionnaire.

The geographical distribution of the plants was also considered. It is reported that the distribution of the plants in the sample fall in line with the actual distribution of the population as a whole. Consequently, the majority of the plants are located in

Northern Spain (60.7% of the sample as opposed to 64.9% of the population). The sample encompasses a variety of manufacturing activities related to manufacturing and assembly of components to OEMs automotive industry. Table 2.1 displays the distribution of the sample in comparison with the population in the most representative industrial activities, whereby similarity in distribution is shown in the sample compared to the population.

Table 2.1. Industry distribution of the sample and the population

<i>ISIC</i>	<i>Industry</i>	<i>Sample</i>		<i>Population</i>	
		<i>n</i>	<i>%</i>	<i>N</i>	<i>%</i>
343	Manufacture of parts and accessories for motor vehicles and their engines	49	58.3	107	49.5
252	Manufacture of plastics products	11	13.1	26	12
319	Manufacture of other electrical equipment	6	7.1	13	6.1
289	Manufacture of other fabricated metal products, metalworking service activities	6	7.1	10	4.6
	Other industries (22 industries)	12	14.4	60	27.8
Total		84	100	216	100

With regard to the distribution of the sample size, 41.7% of the sample is comprised of small plants (up to 249 employees), medium-sized plants (250-499 employees) account for 34.5% of the sample, while large plants (500 or more

employees) account for 23.8% of the sample. At the end, random telephone calls were made to plants that failed to return the questionnaire. As a conclusion, no evidence was found which would have indicated a specific pattern explaining why certain companies failed to respond or reasons for not doing so. Early versus late respondents' data was compared on the assumptions of Armstrong and Overton (1977). There were no statistically significant differences in any of the study variables ($\alpha = 0.05$).

2.4.2. Measures

A great deal of measures was carried out to address the variables included in the research. Firstly, in terms of the implementation of lean production, respondents were asked to evaluate the extent to which statements of the questionnaire in relation to the implementation of certain practices related to lean production applied to their plant, as compared to their industry average. In this sense, 1 signifies much less, 4 indicates a level of about the same as their industry average, while 7 implies a much greater level of implementation. The results of the factor analysis indicate an agreement with the scientific literature, whereas previous researchers often used the same set of items to build the construct variables related to the lean production (see for example Womack and Jones, 1996; Narasimhan et al., 2006; Moyano-Fuentes et al., 2012) (Table 2.2).

Table 2.2. Lean production practices

<i>Factor</i>	<i>Item description</i>	<i>Average</i>	<i>Factor average</i>	<i>Cronbach's Alpha</i>
Lean production practices	Machinery equipment and word processes are in close proximity	5.69	5.06	0.76
	Manufacturing cells	5.42		
	Layout of the plant grants reduced inventory and high- speed manufacturing	5.24		
	Utilization of total quality management	5.12		
	Time is devoted to planning maintenance-related activities on a daily basis	5.07		
	Maintenance is carried out on a regular basis	5.19		
	Utilization of just in time inventory	4.54		
	Utilization of Kanban	4.55		

Second, in case of the workforce development construct, respondents were asked to rate the extent of implementation of workforce development in comparison with the average of their industry. This time, 1 refers to a much lower level of implementation, 4 indicates a level of about the same as their industry average, while 7 implies a much

higher level of application. This construct was then used as an independent variable in the analysis, which falls in line with prior usage of the same construct (Narasimhan et al., 2006) (Table 2.3).

Table 2.3. Workforce development

<i>Factor</i>	<i>Item description</i>	<i>Average</i>	<i>Factor average</i>	<i>Cronbach's Alpha</i>
Workforce development	We are concerned of the active development of the skills of the employees	4.68	4.53	0.87
	Employees are trained to carry out a wide variety of tasks	4.73		
	Employees are encouraged to exchange opinions and ideas	4.79		
	Employees are equipped with a strong ability to solve problems	4.44		
	Problem-solving skills are taken into account during the selection process of the employees	3.99		

Third, in case of the performance of the company, respondents were asked to rate the importance of a set of items related to the operational performance of the company, whereas 1 means very low and 7 means very high, such as used antecedently by Shah and Ward (2003) (Table 2.4.). Finally, control variables were introduced into the model to make up for structural factors. The practice of the introduction of the same kind of

control variables for similar purposes was observed in the literature (Moyano-Fuentes et al., 2012). The age of the company was employed to control for the effects originating from the age of the company, while the number of employees was intended to make up for the impact of the size of the company and percentage of total costs over direct materials and subcontracting (vertical integration).

Table 2.4. Operational performance

<i>Factor</i>	<i>Item description</i>	<i>Average</i>	<i>Factor average</i>	<i>Cronbach's Alpha</i>
Performance	Scrap and rework costs	5.35	5.99	0.67
	Manufacturing cycle time	6.28		
	First pass yield	6.38		
	Labor productivity	5.91		
	Unit manufacturing cost	5.85		
	Customer lead time	6.18		

Prior to the extraction of the factors, the items were included in a Kaiser-Meyer-Olkin (KMO) and a Bartlett measure to investigate the case of sampling adequacy and the sphericity of the sample. Based on the test it is determined that all of the variables were tested acceptable for the KMO test. The Bartlett's test yielded a significance level of 0.050 or below. For a factor analysis to be conducted, a KMO value of at least 0.500 is required (Williams et al., 2012) and the Bartlett's Test of Sphericity should be significant ($p > 0.050$) (Hair et al., 1998). Consequently, the factor analysis became possible to carry out. After the determination of the feasibility of the aforementioned measure, each factor was also subject of a Cronbach's Alpha test. This practice was used antecedently by Sadeghi et al. (2010) and Pinheiro and Zambujal (2012) to measure the internal consistency (reliability) of the constructs. The alphas were returned a value that

is acceptable in all cases. For each construct, convergent validity was demonstrated; each factor had a loading higher than 0.5 (Bagozzi and Yi 1988).

Discriminant validity as previously suggested by Fullerton and McWatters (2001) was also tested for and it was determined that none of the variables had loadings in excess of 0.4 on more than one factor. The measures to ensure construct validity fall in line with other contributions in the literature (Moyano-Fuentes et al. 2012).

Descriptive statistics and Pearson correlations coefficients among the variables used in the analysis are shown in Table 2.5. Significant correlations exist among control, dependent and independent variables, thus requiring this to be taken into consideration in further analyses.

Table 2.5. Means, standard deviations and Pearson correlations coefficients

<i>Variable</i>	<i>Mean</i>	<i>Std. dev.</i>	<i>1.</i>	<i>2.</i>	<i>3.</i>	<i>4.</i>	<i>5.</i>
Performance	5.97	0.72					
Lean production	5.14	0.73	0.26**				
Workforce development	4.53	1.00	0.15**	0.30**			
Number of employees	377.67	276.19	0.01	0.27**	0.24**		
Age of plant	23.89	16.12	-0.11*	-0.17**	0.18**	0.33**	
Purchasing cost	63.43	11.26	-0.02	0.21**	0.06	0.03	-0.20**

Notes: N=84

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

2.4.3. Model testing

Hypotheses 1, 2 and 3: Aforementioned hypotheses were tested by employing hierarchical regression analysis. Following Pedhazur and Schmelkin (1991), this sort of measure enables identification of the percentage of variance which is explained by each independent variable individually. With the aim of testing the first three hypotheses of this paper, the sets of variables were entered the model sequentially, commencing with the control variables (Model 1) and then subsequently including lean production (Model 2), WFD (Model 3). This approach was antecedently widely used in the literature (Moyano-Fuentes et al., 2012; Pedhazur and Schmelkin, 1991).

Hypothesis 4: Moderation can be described as a hypothetical casual chain in which one variable affects a second variable which, in turn, affects a third one. The intermediate variable (M) is the moderator and it moderates the relationship between a predictor (Y) and an independent variable (X). In order to test for the effect of moderation, it is suggested that the researcher use a sequence of steps, such as proposed by Baron and Kenny (1986) (Table 2.6). In this regard, each step involves the conduction of a regression analysis where the significance of the coefficients is investigated. Should the researcher fail to identify significant relationships between the variables in Step 1-3, then it is often concluded that the moderating effect of the moderator variable is possibly not likely. If the variables X and M both remain significant in Step 4, the moderation effect can be presumed. The assessment of moderation has recently been used by Park and Ryu (2015) and by Liao (2015) in terms of performance.

Table 2.6. Testing for moderation

	<i>Analysis</i>	<i>Visual depiction</i>
Step 1	Conduction of a simple regression analysis with X predicting Y. $Y=B_0+B_1X+e$	LP → Performance
Step 2	Conduction of a simple regression analysis with X predicting M. $M=B_0+B_1X+e$	LP → WFD
Step 3	Conduction of a simple regression analysis with M predicting Y. $Y=B_0+B_1M+e$	WFD → Performance
Step 4	Conduction of a multiple regression analysis with X and M predicting Y. $Y=B_0+B_1X+B_2M+e$	LP → Performance and WFD → Performance

Source: Baron and Kenny (1986)

In case of this paper, the following relations have been established based on the above mentioned methodology.

2.5. Results

In case of hypotheses 1 and 2, the results of the hierarchical regression analyses are presented in Table 2.7. Model 1, which comprises only the control variables, does not show any significant relationship between the independent and predictor variables. Model 2 shows that the extent to which lean production is implemented has a significant impact on operational performance. The statistically significant relationship of workforce development on operational performance is depicted in Model 3.

Table 2.7. Analysis of regression of relationship of LP and WFD on operational performance

<i>Independent variables</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Age of Plant	−0.144	−0.058	−0.179***
Percentage of Purchasing Costs	0.053	0.090	0.062
Number of Employees	0.048	0.077	0.125*
Implementation of LP		0.353***	
Workforce Development			0.168***
F	2.867*	2.812***	4.844***
R ²	0.018	0.123	0.057
Adj. R ²	0.012	0.115	0.049

Notes: Values are standardized regression coefficients (β s).

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

In case of hypothesis 3, the results of the hierarchical regression analysis are shown in Table 2.8. Model 4 provides implications about the relationship between the control and predictor variables and one can arrive at the conclusion that some significant connection exists among them. Model 5 investigates the impact of the degree of implementation of lean production on workforce development and points to the existence of a significant relationship. For all the above reasoning, Hypotheses 1, 2 and 3 are supported.

Table 2.8. Analysis of regression of influence of LP on WFD

<i>Independent variables</i>	<i>Model 4</i>	<i>Model 5</i>
Age of Plant	-0.117*	-0.208***
Percentage of Purchasing Costs	0.069	0.037
Number of Employees	0.157**	0.038
Implementation of LP		0.377***
F	8.649***	9.063***
R ²	0.052	0.177
Adj. R ²	0.046	0.170

Notes: Values are standardized regression coefficients (β s).

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Hypothesis 4 is supported, because the analysis confirmed the existence of a moderating effect for the workforce development construct. The results obtained from the moderation model proposed by Baron and Kenny (1986) method suggest that there is a third mechanism in the relationship between the degree of lean production implementation and the operational performance of the company, which according to the results of this paper, is moderated by workforce development practices (Table 2.9).

At this point, the results are summarized with the help of a graphical modeling to comprehend the connections to a greater extent. Results for the moderation effect of the workforce development and implementation of lean production on operational performance are depicted in Figure 2.2.

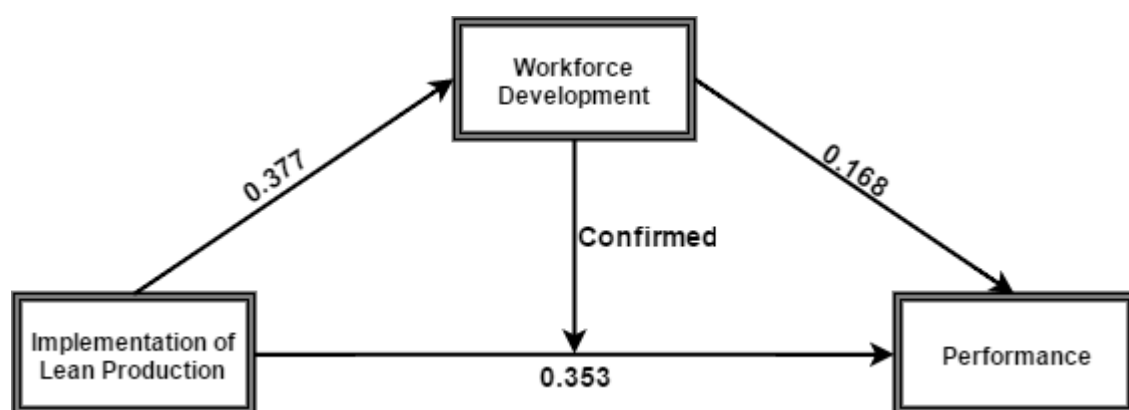
Table 2.9. Results of the regression analyses for Hypothesis 4

<i>Independent variables</i>	<i>Step 1</i>	<i>Step 2</i>	<i>Step 3</i>	<i>Step 4</i>
	<i>LP → P</i>	<i>WFD → LP</i>	<i>WFD → P</i>	<i>LP → P</i> <i>WFD → P</i>
Age of Plant	−0.058	−0.208***	−0.179***	−0.079
Percentage of Purchasing Costs	0.090	0.037	0.062	0.088
Number of Employees	0.077	0.038	0.125*	0.032
Implementation of LP	0.353***			0.338***
Workforce Development		0.377***	0.168***	0.052*
F	2.812***	9.063***	4.844***	4.843***
R ²	0.123	0.177	0.057	0.142
Adj. R ²	0.115	0.170	0.049	0.133

Notes: Values are standardized regression coefficients (β s).

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Figure 2.2. Graphical depiction of the results



Note: Notes: Values are standardized regression coefficients (β s) and are significant at the level of $p < 0.001$.

2.6. Discussion

This work is part of a current research stream which addresses the human factor in lean environments. In this regard, the contribution of present paper can be grabbed in shedding light on the role played by workforce development in the relationship between the degree of implementation of lean production and operational performance. Prior research interest mainly addressed the assumptions of the model of present paper separately. Bonavía and Marín-García (2011) analyzed lean production related advanced human resources practices including the ongoing training of the workforce, while Power and Sohal (2000) outlined the implications of a multi-skilled and flexible workforce in a lean environment.

There is no consensus among researchers about the course of action which provided insight for managers about an explicit procedure to follow, should they desire to begin with the implementation of lean production. The results of this paper reinforce the assumption that during the implementation of lean production workforce development plays a key role due to its nature that advancement in the implementation translates to improved performance.

Besides the identification of positive links among the variables, the major contribution of this study can be grabbed in providing evidence for moderation of workforce development through lean production on operational performance. These findings can be considered a significant step toward the explanation of operational performance outcomes when the degree of lean production implementation and that of workforce development are taken into account in a combined way. The results point out that a company in pursuit of higher operational performance should not only focus on a higher level of lean production implementation, but they should also thrive for using a variety of practices related to workforce development to a greater extent.

This work reinforces the insight on the role of human resources in lean environments. More specifically, it is assumed that progress in implementing lean production contributes to upgrading the knowledge and skills of employees, and by this means improved performance outcomes can be attained. This reaffirms the concept of Shah and Ward (2003) that lean is an integrated socio-technical system oriented to efficiency. To this end, present paper implies that the impact of lean production on operational performance engenders from the improvement of workers' skills and knowledge.

This paper offers crucial implications for managers interested in increasing studying factors which may cause an upshot in operational performance. Investments which facilitate the implementation of lean production should be realized with simultaneous investment in workforce development to increase performance. The findings of this study also point to the important role which HR management possesses in the successful implementation of lean production, which consequently results in augmented performance outcomes. In this regard, HR managers should ensure that the workforce takes part in advanced training practices and their skills are continuously subject to further development. In addition, HR managers should take charge of creating adequate areas and times where workers are encouraged to actively exchange ideas. This may then result in a positive net effect and contributes to improving the company, as hinted by Olivella et al. (2008).

The limitations of this study should be addressed. This research scrutinized the impact of workforce development on performance through the degree of implementation of lean production. With the aim of testing the hypotheses of this paper, a variety of measures were carried out which are considered perceptual in nature. Despite the belief that the returned questionnaires are free of biases, it is impossible to completely rule out

this sort of apprehension. A practical advance would be to test the model of this paper by the employment of multiple informants, not only relying on information provided by the managers.

Furthermore, the dataset of this paper only focuses on the significant suppliers in the automotive industry, therefore any attempt with the aim of concluding universal applicability of the results should be handled with serious attention and consideration. Consequently, an axiomatic extension of this study should appraise the operational environment of the plant to a more comprehensive extent and with a greater focus on second and third tier suppliers in the automobile industry. An additional line of research should make up for the cross-sectional nature of the dataset employed in this paper. In this light, the model of this study should be replicated using longitudinal data which would enable the researcher to gather important insight into time-dependent inferences. Despite these limitations, the data provide useful inferences with regard to the implications of workforce development on the relation between the implementation of lean production and performance.

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CHAPTER 3.

SELF-REFERENCE ON PAST PERFORMANCE AND FIRM RISK AS PREDICTORS OF LEAN PRODUCTION IMPLEMENTATION

3.1. Introduction

In the past three decades, management literature has been calling for an increased amount of attention to augmented corporate competition on the industrial scene. Companies face novel challenges due to constant motion of market conditions. In order for manufacturers to retain their competitive edges and to deal with the necessity to manage the different sources of environmental variability (customer demand, supply chain, environmental shocks, etc.) manufacturing firms have been prompted to adopt the particularly salient management system of lean production (Womack and Jones, 1996). The multi-dimensional approach of lean production (Shah and Ward, 2003) encompasses a variety of management practices (Bhasin and Burcher, 2006) and ultimately aims to eliminate any type of waste or source of internal and external supply chain variability (Shah and Ward, 2007). The main point behind this specific managerial toolset comprises the principles of cost reduction, which is carried out by driving out any unnecessary expenses. Thus, the primary focus is turned to efficiency, while striving for eliminating wasteful bottlenecks (Hines, 2004). So far, the influence of the uncertainty engendered by the external environment with respect to the commitment of the company to implement lean production has been not studied.

In the recent decades, lean production, this sociotechnical system (Moyano-Fuentes and Sacristán-Díaz, 2012) has been in the spate of research interest. Prior to the 1990s, research interest usually addressed the technical aspects of the implementation of lean production (Bonvía and Marin-García, 2011). Then, driven by the recurring

instances of failures, this research scrutiny has shifted towards the investigation of risks involved in the transformation and the management of this process (Marodin and Saurin, 2013). The aim of this paper differs from that of Marodin and Saurin (2013), because present research employs an empirical analysis and complements their research by putting the concept of firm risk into the context of lean production implementation. In addition, this paper reveals important connection between the risk stemming from the external environment of the company, while above authors focused on internal aspects. It is argued that based on past performance variability, risk affects the adoption of complex decisions differently, such as the commitment to implement lean production (Scherrer-Rathje et al., 2009). In this sense, past performance contemplates both environmental variability and the internal management of the company: improved operational output can be attained via obtaining higher sales or offering the same quantity but with reduced costs due to higher efficiency. However, companies have little capacity to address external risk factors due to their intrinsic variability and unpredictiveness. On the other hand, past operational performance can imply more possibilities to deal with results through making use of management systems. Nonetheless, this latter also implies some uncertainties.

In this light, scholars have established two competing theories about how risk affects the decision-making of a company with the first one being the *prospect theory* (Kahnemann and Tversky, 1979) and with the second one being *threat rigidity hypothesis* (Staw et al., 1981). In this paper, a theoretical contribution is provided as well to help settle down the debate between the two aforementioned theoretical approaches on the influence of environmental uncertainty on lean production implantation.

With the aim of achieving the research objectives, present paper is structured into five parts. The introduction part is continued with a theoretical review about lean production and with the development of the hypotheses. The third section outlines the research methodology, while section four draws upon the results of this study. The conclusions and implications are explained in section five.

3.2. Literature and hypotheses

3.2.1. Lean production

In the environment of management, compelled by the growing competition among companies, manufacturing firms were driven to implement new management systems to maintain their competitive advantage. Throughout the last thirty years, there has been a clear trend towards the adoption of lean production (Meredith and McTavish, 1992). Lean production emerged from the 1950s Toyota Production System as an innovative way to manage the growing need for variety in products in a flexible way (Ohno, 1988). The term itself was first coined by Krafcik (1988) and referred to a set of manufacturing practices, which was first used in the Japanese manufacturing industry. As a continuation of his research with the goal of attaining an enhanced comprehension about the challenges of the global automotive industry, Womack et al. (1990) enclosed their findings with the public in their international best-seller called *The Machine That Changed the World*.

Since then *lean production* is described as an integrated sociotechnical system with the aim of eliminating any kind of waste by means of minimizing internal and external system variability to the lowest possible extent (Shah and Ward, 2007) and concurrently enabling the creation of value (Murman et al., 2002). Lean production is aimed at the

attainment of higher efficiency which is achieved by driving out any causes of inflexibilities. This results in an improvement of quality, per unit manufacturing costs and reduced customer lead time which in turn translates to the accomplishment of higher performance outcomes (Womack and Jones 1996).

There is a general consensus within the operation management literature about the “high-performing” lean practices with well-established theoretical and empirical support (Sakakibara et al., 1997; Shah and Ward, 2003; Narasimhan et al., 2006; McLachlin, 1997). Thus, the most characteristic practices of lean production are:

5. Cellular manufacturing
6. Total productive maintenance (TPM)
7. Total quality management (TQM)
8. Kanban
9. Just-in-time production (JIT)

Scholarly journals prefer to address lean production as a set of philosophical tools, emphasizing that it is in a constant evolution and encompasses all levels of the organization (Womack and Jones 1996).

3.2.2. Firm risk

There is no universally accepted definition of risk (Andretta, 2014). This paper adopts the definition of firm risk from Orlitzky and Benjamin (2001, pp. 370.): “Risk is defined as uncertainty about outcomes or events, especially with respect to the future”, while “firm risk measures the amount of financial performance fluctuations over time”

and therefore can be seen as an indication of increased variability in terms of organizational returns. More recently, Kaufmann et al. (2013) devised a classification to communicate risk: numerical description, experience sampling, graphical display and their combination. In case of dealing with risk it is often posited that different types of risk should be done away with via different risk management strategies (Holzman and Jørgense, 2001). The environment of a company can be characterized by a number of external uncertainties and it is crucial for the firm to be able to analyze these risks and come up with an appropriate solution. Managers' ability to provide a suitable resolution may be contingent on their perception and interpretation (Daft and Weick, 1984). In the context of lean production, a number of risks have been identified so far whereas difficulties, barriers and different factors have been considered (White and Prybutok, 2001). These risks are similar in nature because they usually deal with internal uncertainties. The aim of this article, however, is to investigate the impact of a comparatively riskier environment on the strategic decision-making of the firm, that is, the association between higher operational variability and managerial decisions.

Scholars have adopted two diverse lines of argument in the research of risk-taking behavior, forecasting alternative behavioral patterns concerning strategic decisions of a company in an operational environment characterized by different extents of variability. The two opposing theories are the *prospect theory* (Kahnemann and Tversky, 1979) and the *threat rigidity thesis* (Staw et al., 1981; Meschi and Métais, 2015). Interestingly, these two competing theories both have empirical support (Meschi and Métais, 2015; Fiegenbaum and Thomas, 1988; Tsai and Luan, 2016).

The threat rigidity hypothesis posits that companies adopt a rather conservative behavior in case of their decision-making when the variability of the operational

environment is higher. Managers may resort to “constrict information flow, become rigid by applying only tested repertoires, and engage in centralized decision-making (Shoham and Fiegenbaum, 2002, pp. 130.). This process leads companies to abandon or postpone acquisitions (Iyer and Miller, 2008) and results in a higher likelihood to conduct divestitures (Shimizu, 2007). Consequently, threat rigidity hypothesis predicts that companies adopt a rather conservative managerial style in the presence of risk. In reality, this approach hinders the search for creative new solutions (Meschi and Métais, 2015), such as the implementation of lean production.

On the contrary, prospect theory argues that “a firm will behave in a risk-taking manner when the firm is below a self-perceived reference point” (Tsai and Luan, 2016, p. 220). This attitude is further influenced by the aspiration level (Cyert and March, 1963) and strategic reference point (SRP) (Shoham and Fiegenbaum, 2002). Owing to this idea, companies that are below their SRPs, a higher variability in the operational environment facilitates the implementation of less constricted decision-making. In terms of firm risk, this paper adopts the propositions of prospect theory, because it deals “with the relationship between risk attitude and the current position of a firm relative to reference point” in the past (Tsai and Luan, 2016, pp. 220).

3.2.3. Past performance and decision-making

Based on the propositions of prospect theory, companies’ selection of a reference point has an effect on the perception of managers who are in charge of strategic decision-making (Tsai and Luan, 2016). In the scientific literature, researchers demonstrate that companies tend to have a clear preference for selecting reference points for the sake of making strategic decisions based on their past performance (Shoham and Fiegenbaum,

2002). This paper follows afore tradition and employs past operational performance as a focal point for decision-making. In case of lean production, past operational performance can be a feasible option when one would like to explain how past operational results influence strategic decision making, such as in case of this paper, advancements in the implementation of lean production. The items that pertain to past operational performance also correspond to the lean results of lead-time reduction, cost reduction and conformance quality. Therefore, it is contended that the following aspects relate closely not only in conceptual but also in empirical sense to devising the past operational performance (Hall, 1987, Spear and Bowen, 1999; Ross, 2003).

3.3. Hypotheses

While the concept of lean production is a relatively well-understood phenomenon (Shah and Ward, 2003), the drive for its implementation in business is not always clear. Over the past decades, many companies have analyzed their operations and have come up with methods to eliminate waste. The transformation entails a significant investment into an organizational change that affects not only the human resources area (Bonavía and Marin-García, 2011) but technical aspects are also considered (Shah and Ward, 2003). The process, if successfully carried out, brings about improvements in lead-times, per unit manufacturing costs (Womack and Jones, 1996), labor productivity (White et al., 1999), advanced feedback channels (Flynn et al., 1995), better manufacturing cycles (Altekar, 2005) and thus saves valuable company resources. The more efficient manufacturing system (Hines, 2004) is usually linked to increased operational performance (Jabbour et al., 2013) with the notable exception of Belekoukias et al. (2014).

The literature is rich in articles, which put emphasis on the benefits of lean production (Shah and Ward, 2003; Jabbour et al., 2013). Thus, CEOs are encouraged to take advantage of its implementation. This assumption corroborates the suppositions of prospect theory, where there is a relationship between the attitude of managers towards risk and the current position of the company in terms of a relative reference point. In light of afore theory, past operational performance can refer to the environmental uncertainty where the company has maneuverability to improve the efficiency of its processes, reduce costs and increase productivity through the implementation of lean production.

Nevertheless, while there is a scholarly agreement on the performance-related aspects of the implementation of lean production, the motives of this process still lack research scrutiny. Consequently, there is no indication as to why firms with a below average performance opt for its implementation to acquire the benefits associated with it. To sum up, underperforming firms can perceive the implementation of lean production as a “window of opportunity” which helps them achieve their strategic goals with respect to their point of reference in the past. Thus the following hypothesis is proposed.

Hypothesis 1. *There is a negative relationship between past operational performance and the degree of lean production implementation.*

There is an understanding among researchers that the implementation of lean production brings about a major change in the organizational culture of the company (Martínez-Jurado et al., 2014). The success of the transformation process, however, does not equally favor all companies, due to the complexities associated with it (Scherrer-Rathje

et al., 2009). Owing to a greater extent of uncertainties in supply and demand as well as the globalization of the market have resulted in a greater level of risk exposure. This was observed to manifest in a number of different forms (Harland et al., 2003) related to lean production as well. Examples include excessive or mismatched inventory that brings about amassed rework or penalty for the non-compliance of lead-time principles (Christopher and Lee, 2004). Therefore and in keeping with the arguments of the prospect theory (Kahneman and Tversky, 1979), managers' implication of risk in terms of strategic decisions varies greatly based on the circumstances that a company faces (Tsai and Luan, 2016). Some empirical evidence indeed point to corroborate afore assumption (Singh, 1986).

In the face of this, the implementation of lean production could easily be considered as the right response to diminish risks that companies face in a continuously changing environment. In keeping with the provisions of the prospect theory, higher variability in the operational environment of the firm enables the opportunity for the implementation of less constricted decision-making (Tsai and Luan, 2016). Lean production provides a way to deal with production variability and allows the firm to adapt to quick changes in production. In fact, lean production is a set of tools and practices that that may improve efficacy via the adaption to changes in the market while augmenting internal efficiency (Hines, 2004). This rationale leads to the conclusion that firms would opt for the implementation of lean production as an adaptive company behavior in order to increase their capability to deal with riskier environments. This firm behavior is clearly different from agile production, since agile production has the "ability to sense, respond to, and exploit anticipated or unexpected changes in the business environment" (Narasimhan et al., 2006, p. 442.). On the other hand, lean production can be similar to agile production, but the focus is rather on capacity

maximization via the minimization of internal and external system variability (de Treville and Antonakis, 2006). Consequently, the implementation of lean production could be the right response of the firm to cope with firm risk. Thus, the second hypothesis is proposed.

Hypothesis 2. *There is a positive relationship between the firm risk and the implementation of lean production.*

When the external environment becomes harsher for the company, firms are called for the reappraisal of the conceptualization of their organization (Ravasi and Schultz, 2006). In this sense, risk refers to the occurrence of adverse events, such as a contracting market or the appearance of new competitors which result in a decrease in sales. Actions aimed at modifying the external environment, such as changing the regulatory legislation or making use of a new market niche (Chattopadhyay et al., 2001) entail less clear outcomes (Cook et al., 1983). Therefore, firms in such a situation may be prompted to opt for making a strategic decision with respect to their organizational structure (Tsai and Luan, 2016).

Tversky and Kahneman (1981) challenged the views of classical economics in terms of research of risk-taking behavior of managers. Incorporated in the theoretical framework of prospect theory, *reflection effect* postulates that managers are inclined to engage into a risk-seeking behavior when the aim corresponds to mitigation of losses. Therefore, managers are expected to be either risk-seeking or risk averse, depending on the conditions they face (Wiseman and Gomez-Mejia, 1998). This theory then received a great deal of support at the organizational level. In this light, March and Shapira

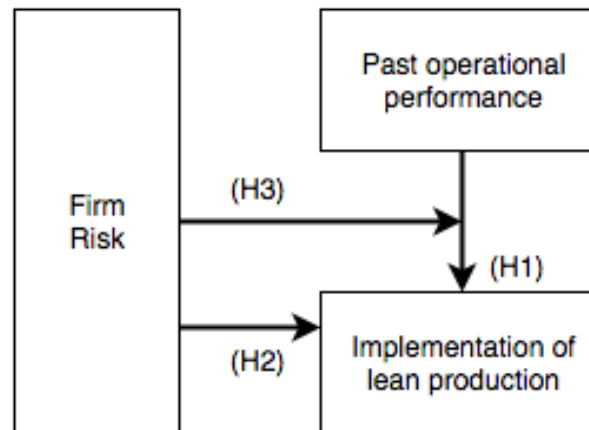
(1987) argued that managers are expected to conduct a risk-seeking behavior when the company faces a higher variation in its operational environment.

Studies that were carried out antecedently empirically prove that a lower performance would be linked to risk-seeking behavior (Bromiley, 1991; Palmer et al., 1995). For instance, Chattopahyay et al. (2001) analyzed a diverse sample with the inclusion of manufacturing organizations and health care services and came to the conclusion that past poor performance and risk-seeking conduct are positively linked. For instance, Tsai and Luan (2016) used the variable sales growth when they investigated the connections between past performance and risk. The implementation of lean production itself implies these uncertainties described above with respect to the performance outcomes of the transformation process would diminish as the implementation evolves (Martínez-Jurado et al., 2014; Scherrer-Rathje et al., 2009).

Thus, managers facing riskier environments, with higher operational variability, would be prompted to quicker implement promising, powerful practices, such as lean production, if they are aware of their past under-performance. Riskier environments would therefore encourage managers to implement lean production if they perceive that their relative position regarding operational performance is weaker. In this sense, firm risk may affect the relationship between past operational performance and the implementation of lean production such as proposed in the following hypothesis. The theoretical framework of this paper is depicted in Figure 1.

Hypothesis 3. *The negative relationship between past operational performance and lean production implementation is stronger when operational risk is higher.*

Figure 3.1. The hypothesized model of the paper



3.4. Research methodology

3.4.1. Data collection and sample characteristics

The empirical context of this study considered the automotive industry due to the fact that companies found in this sector have always been the most receptive to the implementation of lean practices ever since the “Toyota Miracle”. The population was derived from the database of the Spanish Automotive Equipment and Components Manufacturers Association (SERNAUTO) making use of data from a sample of manufacturing plants, which are first tier suppliers to OEMs (Original Equipment Manufacturers) in the Spanish automotive industry. SERNAUTO lists all equipment and component manufacturers in Spain with the aim of producing periodical reports and statistics from the equipment and component manufacturing industry. These studies contain important knowledge about the structural and organizational attributes of each

manufacturing plant in the automobile industry. The database can then be used for scientific research purposes (Moyano-Fuentes et al., 2012, Martínez and Perez, 2003). SERNAUTO's final database (as of December 31, 2007) was made up of a total of 216 manufacturing plants belonging to 74 different first tier supplier companies.

A questionnaire was then developed, which included questions related to organizational characteristics, human resources, the extent to which lean principles and practices are taken use of, supply chain management and past performance outcomes. High ranking informants (they held titles such as CEOs) of the companies from the sample were then contacted in order to obtain more valuable information (following Phillips (1981)). The questionnaires were distributed in early 2008 by means of e-mail, conventional postal delivery services. In addition, with the aim of facilitating the attainment of the highest possible number of responses, an internet-based survey was also presented. Each questionnaire was accompanied by an explanatory note that highlighted the purpose of the research and encouraged CEOs to participate. After a follow-up process carried out by telephone, 84 duly completed questionnaires were retrieved, corresponding to a response rate of approximately 39% and gives a sample error of +/- 8.54% with a confidence level of 95%.

After collecting the questionnaires, it was determined that the geographical distribution of the plants in the sample falls in line with the actual distribution of the population as a whole, with the majority of the plants being located in Northern Spain (60.7% of the sample as opposed to 64.9% of the population). The activity of the plants is strongly related to manufacturing and assembly of components in automotive industry (Table 1). 41.7% of the sample is comprised of small plants (up to 249 employees), and 34.5% medium-sized plants (250-499 employees), whereas large plants (500 or more employees) account for 23.8% of the sample. Random telephone calls were made to

plants that did not return the questionnaire in order to discover why certain companies did not send back any questionnaire, but specific pattern was revealed. Early versus late respondents' data was compared (Armstrong and Overton, 1977), but the data indicated no significant differences in any of the study variables ($\alpha = 0.05$). Response bias was also examined by comparing the sales of the companies in the sample and in the population. No significant differences were observed, which implies that the sample used is representative of the population.

Table 3.1. Industry distribution of the sample and the population

<i>ISIC</i>	<i>Industry</i>	<i>Sample</i>		<i>Population</i>	
		<i>N</i>	<i>%</i>	<i>N</i>	<i>%</i>
343	Manufacture of parts and accessories for motor vehicles and their engines	49	58.3	107	49.5
252	Manufacture of plastics products	11	13.1	26	12
319	Manufacture of other electrical equipment	6	7.1	13	6.1
289	Manufacture of other fabricated metal products, metalworking service activities	6	7.1	10	4.6
	Other industries (22 industries)	12	14.4	60	27.8
Total		84	100	216	100

3.4.2. Measures

A variety of analysis techniques was employed to address the variables included in the research. In case of the **implementation of lean production**, a construct variable was devised. Respondents were asked to evaluate the extent to which statements of the questionnaire in connection with the implementation of certain practices related to lean production applied to their plant in comparison with their industrial average. (1= much less, 4= about the same as their industry average, 7= much greater). To determine the underlying practices which comprise the implementation of lean production variable, a factor analysis was carried out. Recently, based on the suggestions of Shah and Ward (2003) there is a preference for researchers to investigate lean production as a bundle, rather than individual practices (for example: Furlan et al., 2011; Zirar et al. 2015; Bortolotti et al., 2015). An agreement is indicated with the scientific literature, whereas previous researchers often relied on using the same set of items to build the construct variable related to the lean production (see for example Womack and Jones, 1996; Narasimhan et al., 2006; Moyano-Fuentes et al., 2012) (Table 2). This was then used as the dependent variable of the analysis.

Firm risk was measured as the coefficient of variation of net income and used as an independent variable in the analysis. It was calculated for each company by dividing the standard deviation in their net income with the mean thereof. The coefficient of variation represents the ratio of the standard deviation to the mean, and it is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from each other (Miller and Reuer, 1996).

Table 3.2. The implementation of lean production construct

<i>Factor</i>	<i>Item description</i>	<i>Average</i>	<i>Factor average</i>	<i>Cronbach's Alpha</i>
Lean production practices	Machinery equipment and word processes are in close proximity	5.69	5.06	0.76
	Manufacturing cells	5.42		
	Layout of the plant grants reduced inventory and high-speed manufacturing	5.24		
	Utilization of total quality management	5.12		
	Time is devoted to planning maintenance-related activities on a daily basis	5.07		
	Maintenance is carried out on a regular basis	5.19		
	Utilization of just in time inventory	4.54		
	Utilization of Kanban	4.55		

In fact, coefficient of variation “is the recommended statistic to isolate real risk from other dimensional effects when comparing the variability of several batches of data with different distributions across various time periods” (Gómez-Mejía et al., 2007, p. 121). In keeping with previous studies, risk is often defined as the unpredictability of income stream (Figenbaum and Thomas, 1988; Bromiley, 1991), where a greater variance in the companies’ income corresponds to a higher unpredictability in their income and therefore is associated with more risk. Data for computing this variable was derived from the SABI (Iberian Balance Sheet Analysis System) database, which provides commercial information about the most important Spanish and Portuguese enterprises

(Diéguez-Soto et al., 2014; Basco and Voordeckers, 2015). Following Tsai and Luan (2016), the variances three years prior to 2007 were calculated and averaged for each company to obtain a single number using the following equation:

$$\sqrt{\frac{\sum (x - \mu)^2 / n - 1}{\sum x / n}}$$

Past operational performance of the company was measured by the importance of a set of items related to the past operational performance of the company. On this scale, respondents had to evaluate and compare the operational performance indicators of their respective companies three years prior to the submission of the questionnaire. Subjective performance measures can be adequately used in this case, In cases like this, researchers usually resort to using subjective performance measures due to the difficulties arising from the conceptualization of performance (Dess and Robinson, 1984). In the literature, there are examples of taking use of the same group of items for similar purposes, such as Shah and Ward (2003) (Table 3). This was then used as an independent variable in the analysis.

Control variables were introduced in the regression models as well with the aim of making up for structural factors. The practice of the employing the same kind of control variables for similar purposes was observed in the literature (Moyano-Fuentes et al., 2012; Cagliano et al., 2006). The number of suppliers was used to control for the effects originating from the complexity of the supply network of the company, while the size of the company was employed to compensate for the differences that arise from the size.

The age of plant was intended to make up for effects stemming from the age of the company.

Table 3.3. Past operational performance

<i>Factor</i>	<i>Item description</i>	<i>Average</i>	<i>Factor average</i>	<i>Cronbach's Alpha</i>
Performance	Scrap and rework costs	4.72	5.90	0.79
	Manufacturing cycle time	5.20		
	First pass yield	5.89		
	Labor productivity	4.78		
	Unit manufacturing cost	5.18		
	Customer lead time	5.92		

This paper employed a factor analysis to create the underlying constructs. Prior to the extraction of the factors, sampling adequacy and sphericity of the sample were investigated with a Kaiser-Meyer-Olkin (KMO) and a Bartlett test. It was suggested by William et al. (2012) that for a factor analysis to be conducted, the KMO test should return a value of at least 0.500, whereas the Bartlett's Test of Sphericity should be significant ($p > 0.050$) (Hair et al., 1998). After having satisfied the criteria, the factor analysis could be carried out. Cronbach's Alpha test was used to determine internal consistency (reliability) of the constructs (Sadeghi et al., 2010; Pinheiro and Zambujal, 2012). The alpha values were within the acceptable limits. Convergent validity was demonstrated as well; each factor had a loading higher than 0.5 on a given construct (Bagozzi and Yi 1988). Finally, since none of the variables had loadings in excess of 0.4

on more than one factor, the criteria of discriminant validity as suggested by Fullerton and McWatters (2001) was also demonstrated.

Descriptive statistics and Pearson correlations coefficients among the variables used in the analysis are shown in Table 4.

Table 3.4. Means, standard deviations and Pearson correlations coefficients

<i>Variable</i>		<i>Mean</i>	<i>Std. dev.</i>	<i>1.</i>	<i>2.</i>	<i>3.</i>	<i>4.</i>	<i>5.</i>
Past operational performance		5.90	1.063					
Implementation of lean production		5.06	1.148	0.34**				
Firm risk		1.63	1.402	-0.08***	0.18**			
Age of plant		24.69	16.71	-0.15	-0.17	0.19*		
Number of suppliers		64.74	11.03	0.07**	0.17**	0.02*	-0.20	
Number of employees		377.7	276.2	-0.02	0.29**	0.17	0.31**	0.05

Notes: N=84

*** :Correlation is significant at the 0.001 level (2-tailed).

** :Correlation is significant at the 0.01 level (2-tailed).

* :Correlation is significant at the 0.05 level (2-tailed).

3.4.3. Model testing

Hypotheses 1 and 2 were tested by the employment of a hierarchical regression analysis. Drawing upon Cagliano et al. (2006), this sort of measure enables the assessment of the percentage of variance explained by the independent variables separately. Division of

variance via a hierarchical regression model is a desired methodological option when a certain amount of correlation is observed among the independent variables (Moyano-Fuentes et al., 2012). With the aim of testing the initial hypotheses, the sets of variables were entered into the model sequentially, starting with the control variables (Model 1) and then subsequently including risk (Model 2) and finally operational performance (Model 3) (Pedhazur and Schmelkin, 1991).

In the case of *Hypothesis 3*, moderation was scrutinized using the methodological approach of Baron and Kenny (1986). Following this, moderation (or partial mediation) is described as a hypothetical casual chain in which one variable affects a second variable which, in turn, affects a third one. The intermediate variable (M) is the moderator and it moderates the relationship between a predictor (Y) and an independent variable (X). The test of moderation comprises the conduction of a sequence of steps, whereas in each step, a regression analysis is performed and the significance of the regression coefficients is investigated. If the variables X and M both remain significant in the ultimate step, the moderation effect can be surmised (Zhao et al., 2010). Moderation has been widely investigated in operations management, with some recent examples being Park and Ryu (2015) and Liao (2015).

3.5. Results

In keeping with hypotheses 1 and 2, the results of the hierarchical regression analyses are presented in Table 5. Model 1, which comprises only the control variables, does not show any significant relationship between the independent and predictor variables. Model 2 shows the results of the first hypothesis. Hypothesis 1 predicts that the association between past operational performance and lean production implementation is negative. This is supported by the data, which leads to the acceptance of hypothesis 1.

Model 3 reports the results that firm risk is positively linked to the degree of the implementation of lean production. Therefore, hypothesis 2 is supported.

Table 3.5. Results of the regression analyses on implementation of lean production

<i>Independent variables</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Age of plant	-0.287*	-0.231	-0.394**
Number of suppliers	0.086	0.102	0.104
Number of employees	0.386***	0.362**	0.383**
Firm risk	–	–	0.242*
Past operational performance	–	-0.298**	–
F	2.177**	5.360**	3.421*
R ²	0.179	0.265	0.345
Adj. R ²	0.145	0.224	0.272

Notes: Values are standardized regression coefficients (β s).

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Table 3.6. Results of the regression analyses for Hypothesis 3

<i>Independent variables</i>	<i>Step 1</i>	<i>Step 2</i>	<i>Step 3</i>
	<i>P → LP</i>	<i>R → P</i>	<i>R → LP</i>
			<i>P → LP</i>
Age of plant	-0.231	-0.194	-0.415**
Number of suppliers	0.102	0.036	0.093
Number of employees	0.362**	-0.101*	0.406**
Firm risk (R)	–	0.177***	-0.290**
Past operational performance (P)	-0.298**	–	0.254**
F	5.360**	1.231***	3.563**
R ²	0.265	0.125	0.425
Adj. R ²	0.224	0.083	0.343

Notes: Values are standardized regression coefficients (β s).

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Hypothesis 3 is also supported, because the analysis confirmed the presence of a moderating effect between past operational performance and implementation of lean production. This suggests that a third mechanism affects the relationship between past operational performance and the implementation of lean production, thus firm risk acts as a moderator (Table 3.6).

3.6. Discussion and conclusion

It is crucial to have environmental uncertainty in mind when making strategic decisions. There is a current trend in business evolution that as a consequence of the changing market environment, risk is becoming more prevalent (Harland et al., 2003). Therefore, it is important that managers identify risk from a multidimensional context (Clemons, 2000). In the context of lean production, the implementation process entails a strategic change (Scherrer- Rathje et al., 2009) where failure was observed to be an inherent danger, especially in the initial stage of the implementation of lean production (Martínez-Jurado et al., 2014). There is an accepted view among scholars that companies pursue the implementation of lean production as a result of the benefits associated with it, such as increased efficiency (Hines, 2004), lower system variability (Shah and Ward 2007), improved product quality, reduced per unit manufacturing costs and lead time (Womack and Jones 1996), which then contribute to an increase in operational performance (Vázquez et al., 2007).

Ever since the Toyota Miracle (Womack et al., 1990), a number of aspects of lean production have been in the crossfire of research interest, such as technical (Bonavía and Marin-García, 2011) and human-related phenomena (Martínez-Jurado et al., 2013). While these lines of research make explicit mention to the risks, which are encompassed in the transition process, they usually fail to consider firm risk when it

comes to making the decision of going lean. This happens because research scrutiny has focused more on the controllable aspects of the company or maneuverability in managing the implementation process. Nonetheless, this attention has not taken into account the influence of risk that is originating from the variability of the environment and the variability of past performance, which is only partially manageable by the company. To this end, present research takes a unique and idiosyncratic approach in explaining the circumstances that ultimately lead to the implementation of lean production.

The results of this study corroborate the assumption of prospect theory (Kahnemann and Tversky, 1979). This thesis argues that firms are more likely to embark on a radical change, in this case the implementation of lean production, if the environment that directly affects the company is characterized by higher risk. For this reason, this paper can be comprehended as a significant theoretical contribution towards explaining the underlying motives as to why certain firms are more prone to implement lean production.

This paper also contributes to evidence-based findings in support of the prospect theory to gain a better insight about how persistent risk factors can facilitate the risk-seeking behavior of companies. The theoretical debate about the underlying motives for CEOs to embrace risk is still unfolding. On the one hand, prospect theory has recently received considerable support in distinct fields of study (Barberis et al., 2016; Ebert and Struck, 2015), whereas the assumptions of the thread rigidity thesis have also been supported by previous research (Shimzu, 2007; Tsai and Luan, 2016). Therefore, this study can be regarded as a contribution to settle this discussion, however, further streams of research need to provide additional evidence for the conclusion of the debate.

Accordingly, present research offers CEOs important practical implications. In a highly competitive environment, the incomppliance with performance targets, thus lagging behind competitors is common. Therefore, decision-makers should not only consider their relative past performance of their respective company but also the firm risk their enterprise is situated in. In the face of this, the contemplation of the implementation of lean production seems a feasible option. Even so, it entails the possibility of dealing with threats via the advantages associated with lean production and can result in favorable outcomes (Kiymaz, 2015) such as increased performance and reduced operational risk.

This study also provides additional empirical evidence on that lean production can be an appealing strategic option even in situations in which the external environment would not be apparently favorable. We have confirmed that a low past performance together with a higher operational risk it is not indeed a drawback for companies interested in embarking in lean implementation but rather it would a powerful spur. In fact, this study could be used as a teaching resource for future managers to explain crisis management options and how lean production can be taken into account as a feasible alternative in unstable environments. Current managers could be also reassured before and during the process of making the decision towards lean production implementation, particularly if their companies are going through difficult, uncertain periods. Studies like this would reinforce the so-called locus of control for managers involved in risky decision making process under demanding circumstances. Furthermore, this study would be used as an evidence for production and operations managers to justify lean production implementation in front of corporate governing bodies, particularly in situations of high volatility.

The paper has certain limitations as well. First, this study used a variety of perceptual variables with the aim of testing the hypotheses. Even though the questionnaires and the survey process were controlled for biases, the apprehension that they are not bias-free cannot be completely ruled out. Second, the research is bound by the fact that the scope covers only the automotive industry and the sample stems from a particular country. Therefore, doubts can be cast on the generalizability of the implications of the empirical evidence to other industries and other countries of the world.

Therefore, an axiomatic extension of the paper could resolve restriction regarding the generalizability and validate its explanatory power by scrutinizing the operational environment of the plant to a more comprehensive degree while simultaneously a greater focus could be provided on the second and the third tier suppliers in the automobile industry or in such a case, expand the study to investigate a number of different industrial sectors. Another future research direction would consist in a longitudinal analysis by which it would be possible to study if operational risk can be actually reduced after the implementation of lean production.

3.7. References

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